BIORESEARCH MODULE DESIGN DEFINITION AND SPACE SHUTTLE VEHICLE INTEGRATION

FINAL PROGRESS REPORT

VOLUME 2 - PRELIMINARY SPACECRAFT DEVELOPMENT PROGRAM PLAN

December 15, 1971

GENERAL ELECTRIC
Space Re-entry Systems Programs
RE-ENTRY & ENVIRONMENTAL SYSTEMS DIVISION
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FINAL REPORT FOR THE STUDY OF A BIORESEARCH MODULE DESIGN DEFINITION AND SPACE SHUTTLE VEHICLE INTEGRATION

VOLUME 2

PRELIMINARY BIORESEARCH MODULE DEVELOPMENT PROGRAM PLAN

15 December 1971

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for

Ames Research Center
National Aeronautics and Space Administration

GENERAL ELECTRIC
Re-entry & Environmental Systems Division

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I. INTRODUCTION

The Re-entry and Environmental Systems Division (RESD) of the General Electric Company is pleased to submit this document covering the Final Report for the Study of a Bioresearch Module Design Definition and Space Shuttle Vehicle Integration. This document has been prepared under NASA/ARC Contract NASA/ARC Contract NAS 2-6523 and submitted in response to contract Specification and Work Statement A-17193 and related specifications and attachments.

The objective of the study was to use the baseline preliminary design developed for the Bioexplorer spacecraft under the previous NASA/ARC Contract NAS 2-6027, and devote further study effort in areas of thermal control, attitude control and power subsystem design, and evaluate the use of the Space Shuttle Vehicle (SSV) as a potential launch and recovery vehicle for the Bioresearch Module (formerly called Bioexplorer).

The results of the study are to include: a refinement of the baseline design definition of a Bioresearch Module as a Scout-launched payload to accomplish Missions I & II as defined in the specification; an evaluation of the design impact of using the SSV to launch the Bioresearch Module for Missions I, II, and III and recover Missions I and II; and a preliminary definition of the Space Shuttle Vehicle/Bioresearch Module interfaces involved in the conduct of the missions defined.

The Final Report is submitted in three (3) volumes. Volume 1 contains the results of the technical work performed during the study in accordance with the contract work statement. Volume 2 presents the updating and modifications to the Preliminary Spacecraft Development Program Plan developed under Contract NAS 2-6027 as influenced by the results of the changes or revisions to the design, development, fabrication and test programs as determined and evaluated during the conduct of this Bioresearch

Module Study. Volume 3 - the Management and Funding Plan provides a description of the proposed project organization; communications; documentation and reports; project planning, direction and control; related experience and facilities; and cost estimate data and options for the implementation of the Bioresearch Module development program.

This is Volume 2 - Preliminary Bioresearch Module Development Program Plan.

The experienced systems engineering and design and analysis personnel, as well as senior quality assurance, manufacturing and test personnel, who were available at GE-RESD from the recently completed NASA Bioexplorer Study Program were utilized to conduct and support the study phase and spacecraft development planning for the Bioresearch Module Project.

Besides fulfilling the final report requirements of the Bioresearch Module Study Contract, GE-RESD hopes that the material furnished in these three volumes can serve as a basis for continued work and planning leading to the crystallization and implementation of a viable and on-going Bioresearch Program. To any future development phases, GE-RESD offers its unique resources of experienced technical and management personnel, facilities and flight-proven hardware designs resulting from the development and flight of numerous space systems programs, including its demonstrated performance and directly applicable experience from NASA's series of Biosatellite space biology missions.

GE-RESD welcomes the opportunity to be of additional service to the Bioresearch Module Project in terms of preparing and/or conducting presentations and proposals which NASA/ARC may consider useful to the interpretation of the material furnished herein or to the contribution of follow-on program implementation planning.

II. PRELIMINARY BIORESEARCH MODULE DEVELOPMENT PROGRAM PLAN

1.0 INTRODUCTION

This document describes the General Electric Company, Re-Entry and Environmental Systems Division (GE-RESD) planning, schedules, direction and management necessary to effectively perform the design, development, evaluation and flight of two (2) Type I and two (2) type II Bioresearch Modules (BRM).

CONTRACTUAL DOCUMENTS

(1) Specification A-17193

1.1 OBJECTIVE

To provide a plan and associated schedules required to design, develop, test, evaluate and fly a Bioresearch Module as defined by Specification A-17193.

1.2 SCOPE

GE-RESD will complete the design, development, fabrication, assembly, test and evaluation of a Bioresearch Module (Types I and II). Scout shall be used as the initial launch vehicle with later adaptation to Space Shuttle.

1.3 RESPONSIBILITIES

(1) Overall management and direction
Bioresearch Project: NASA/ARC.

(2) Coordination launch vehicle design
Interface: NASA/ARC.

(3) Coordination experiment design
Interface: NASA/ARC.

(4) Bioresearch Module design, development, fabrication, assembly, test, evaluation and delivery: GE-RESD.

(5) Bioresearch Module, AGE, design, development, fabrication, assembly, test and delivery: GE-RESD.

(6) Bioresearch Module launch preparation (Wallops Island) and flight evaluation support: GE-RESD.

2.0 MANAGEMENT PLAN

The Management and Funding Plan for the Bioresearch Module Program is contained in Volume 3, which covers Organization and Personnel, Program Management, Project Direction and Controls, Financial Plan, Management Requirements, and Documentation Requirements.

3.0 ENGINEERING PLAN

3.1 SYSTEMS ENGINEERING

3.1.1 Specifications

GE-RESD will provide the systems engineering required to maintain the specification trees (see Figure II.1-1) for each of the two mission types. A Systems Specification, a BRM/Experiment Interface Specification, an Internal-External Environment Specification and a Launch Vehicle Requirements and Restraints Document will be prepared and maintained as part of the system engineering effort.

3.1.2 Aerodynamics

The BRM mass properties will be investigated to obtain information to be used for refining orbit decay predictions. An analysis of the long- and short-term motion characteristics of the Type II mission BRM will also be performed.

3.1.3 Thermodynamics

Thermal analyses will be performed to determine thermal louver emittance and absorbtance characteristics as a function of cold plate optical properties and louver opening angle. Orbit environment sink temperature analysis will be performed to determine the

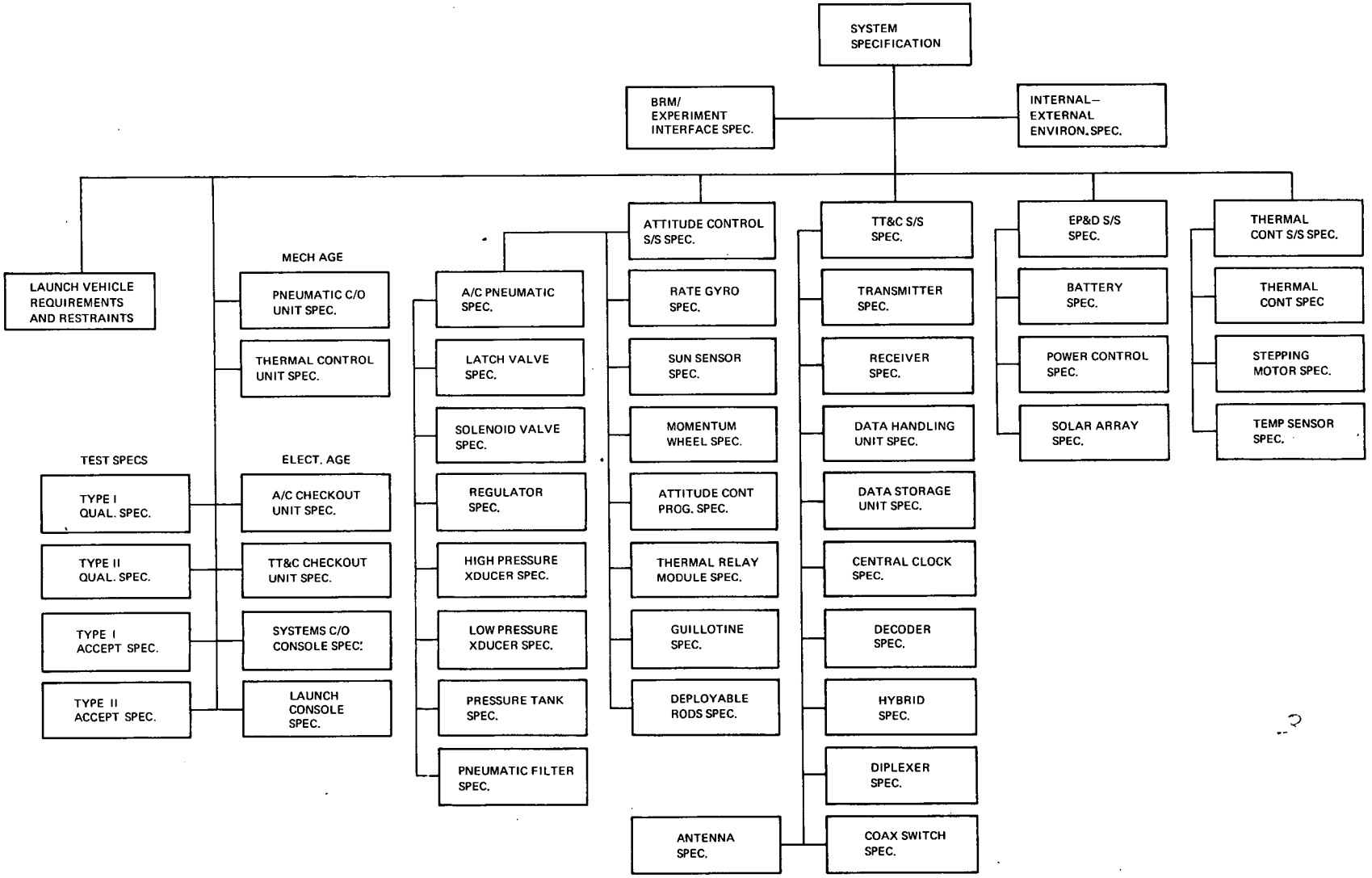

Figure II.1-1. Specification Tree Bioresearch Module

range in sink temperatures as a function of orbit parameters for each of the mission types. Cold plate steady state and transient thermal characteristics will be analyzed and calculations made of thermal gradients and finning effects. The analysis will result in definition of requirements of cold plate area and thickness.

Thermal analyses will also be performed for electronic components and thermal design requirements will be determined. A thermal analysis of the solar array will be performed to define solar cell and structure steady-state and transient temperature response as a function of environments and optical properties.

3.1.4 Structural Mechanics

The structural mechanics effort will include the establishment of dynamic environments and dynamic test criteria for the BRM experiment package and components; inputs will be provided to the external and internal environment specifications. Frequency analyses will be performed of the spacecraft in the cantilevered "on booster" configuration in order to provide the Booster Contractor with required information for payload compatibility studies. Dynamic analysis of the BRM will be performed to determine structural response and loading due to powered flight shock, vibration and acoustic environments.

The effort will also include an investigation of the effect of the bumper on acoustic energy transmissions and an analysis of solar panel design to optimize frequency characteristics for both the stowed and deployed configurations.

A structural loads and criteria document will be prepared. The purpose of this document will be to define the structural requirements philosophy and loads to be used in the design of the Bioresearch Module. The environments to be investigated include ground handling, transportation, storage, powered flight, separation, and orbital flight. (Thermal effects are included in these environments). This document will be issued in a preliminary form to be used in early design and will be updated and reissued for final design.

A preliminary stress analysis for the structural elements of the BRM will be performed to verify the structural integrity of the early design. This document will define for each part (ring, longeron, etc.) the critical loading condition, and the minimum margin of safety for the part.

A final stress analysis will be issued to verify the structural integrity of the final design. The analysis will utilize the updated loads document and will include the design changes which occur between early design and final design.

After completion of ground tests, an addendum to the final stress analysis will be issued to cover any changes that may have been required due to the ground tests. This will result in a document consisting of the final stress analysis plus addenda which will be consistent with the released design.

In addition to producing these documents, the structural engineer will participate in structural trade-offs during the evolution of the design, including primary structure, component supports, solar panels and attitude control system.

3.1.5 Flight Mechanics

The flight mechanics effort will include analysis of the orbit decay characteristics, decelerations in orbit and orbit insertion uncertainties to define the required target orbit attitudes and integration of the resulting information with launch vehicle performance and capability.

3.1.6 Materials

The materials support will include a review of system design analyses and tradeoffs to evaluate material candidates for components such as solar system panels, cold plate, attitude control system etc. Technical inputs will be provided on material compatibility, fabricability, adequacy of corrosion resistance and stress corrosion protection. Materials aspects of design and specification controls will be reviewed to

ensure material compatibility, fabricability, adequacy of dissimilar metal and/or organic interfaces from a corrosion resistance aspect. Metallic interface compatibility, coatings and lubricants will be evaluated from the standpoint of operation for extended periods in thermal vacuum conditions.

3.2 SUBSYSTEMS ENGINEERING

GE-RESD will perform the required design and development of the Bioresearch Module (BRM) as defined below. A stage release system for specifications and drawings will be used to provide an organized method of releasing detailed design engineering information in an integrated manner for the BRM subsystems and components. The testing referenced herein will be defined in the Integrated Test Program Plan.

3.2.1 Structure

GE-RESD will perform design, development and test of the following assemblies:

(1) Experiment Compartment
(2) Experiment Mounting Adapter
(3) Service Module Assembly
(4) TT&C Subsystem Module Mounting Structure
(5) Attitude Control Subsystem Module Mounting Structure
(6) EP&D Subsystem Module Mounting Structure

The assemblies listed above will comprise the Bioresearch Module structure.

GE-RESD will perform the analyses required to finalize the design of the BRM structure. An engineering mockup will be constructed to be used in evaluation of the modular concept in terms of accessibility of components and the ability of the structure to withstand expected environments. One BRM structure will be fabricated for use in BRM development tests, a second structure will be fabricated as part of the prototype BRM and will undergo systems qualification testing.

Support will be provided to manufacturing for procurement of vendor components and for preparation and review of development and qualification test plans. On-line test

support and post test data evaluation and reporting will be provided for the development and qualification tests.

3.2.2 Electrical Power and Distribution

The Electrical Power and Distribution (EP&D) will provide and distribute power, for all phases of the mission, to the on-board experiment and to the Bioresearch Module subsystems. Electrical power will be supplied by an on-board solar array and battery during the mission and by ground equipment before launch. GE-RESD will perform trade-offs and analyses leading to the final EP&D subsystem definition, including power distribution techniques, load combinations, optimum bus voltage and solar array/battery voltages, regulation approaches and requirements, connector and cable selections, solar array and battery sizing and trade-offs and allocation of power of subsystems.

An Electrical System/Subsystem Design Specification will be issued and maintained. The specification will include design and test requirements, component baseline definitions, grounding and shielding philosophy, interface baseline documentation (experiment, launch vehicle and AGE), mission profile and electrical sequence of events, power quality, power budget, and reliability.

An EMC Control Plan covering design and test requirements and EMC management philosophy will be prepared and maintained. The subsystem design and test activity will be monitored to ensure that all EMI requirements are met.

The modular signal and power distribution concepts required for modular subsystem testing will be finalized. Trade-offs of power distribution concepts will be accomplished including ac vs dc and centralized vs. distributed conversion from the standpoints of weight, testing, EMI and risk.

Requirements will be generated for development and qualification testing of the EP&D subsystem and test support, data evaluation and test report inputs will be provided.

3.2.3 Telemetry, Tracking and Command

The Telemetry, Tracking and Command (TT&C) subsystem will store digital data from the Bioresearch Module for transmission to ground stations on command along with BRM and experiment telemetry signals. Selectable, redundant S-band telemetry transmitters will be provided. Redundant, tone sequential command receivers and decoders will be provided to allow complete control of Bioresearch Module operations by flight controllers.

Patchboards will be provided for the experiment package analog data channels and commands. Timing signals are provided to the experiment package and to turn telemetry off 12 minutes after the telemetry is commanded "on". Mission elapsed time will be transmitted to the ground stations via telemetry.

The subsystem will be compatible with the NASA Manned Space Flight Network (MSFN).

GE-RESD will perform trade-offs and analyses leading to the synthesis of the TT&C subsystem. Command and Data Lists and link calculations will be prepared and maintained. Information will be generated to support reliability and EMC analyses, operations planning and TT&C interface requirements definition. Subsystem development tests requirements will be defined and test and evaluation support will be provided for development and qualification tests.

A MSFN compatibility test will be conducted using engineering development hardware.

3.2.4 Attitude Control

GE-RESD will design, develop and test an attitude control subsystem for mission Types I and II. Common to these mission types will be the sun sensors, pneumatic control and gas storage assemblies, redundant rate gyro packages, and the programmer/jet controller. However, only the sun sensors and pneumatic control assembly will be interchangeable between the mission peculiar Bioresearch Module configurations.

The Attitude Control subsystem for the Type I mission will include a constant speed momentum wheel while the Type II mission attitude control subsystem will be provided with extendable rods used to vary spacecraft spin rate.

GE-RESD will perform analyses and trade-offs leading to the final definition of the attitude control subsystem design. Design and analysis studies will be performed to determine spacecraft motion and the use of extendable rods. Support will be provided for vendor and in-house testing of rods. Requirements will be provided for the design of attitude control AGE.

Direction and support will be provided for component and subsystem development tests and AGE breadboard and development tests. Attitude control qualification test requirements will be defined and test and data evaluation support will be provided. An operational analysis of the attitude control subsystem operation will be performed to develop information to be used for operations planning.

3.2.5 Thermal Control

Thermal control of the experiment will be provided by controlled radiation of heat from a cold plate using thermal louvers.

The plate radiating area will be coated with a thermal control coating having a low IR hemispherical emittance (less than 0.25) and a high solar hemispherical absorptivity (greater than 0.80). A stepping motor and gear train will be provided to control the opening area of the louvers. The control system will consist of sensors on the cold plate, a digital controller, and a stepping motor to drive the gear train. An engineering model of the louvers and associated linkage will be constructed and measurements made of required torque under normal operating conditions, worst case and off design conditions. A breadboard of the electronic controller will be fabricated and measurements made of pulse rate vs. error for the range of operating conditions. The drive mechanism and breadboard controller will be assembled, measurements will be made of torque vs. pulse rate for operating and off design conditions. The drive mechanism

and breadboard will be connected to the louvers and responses to step thermal inputs will be measured. The hardware will then be updated and packaged for thermal vacuum testing.

Subsystem engineering support will be provided to spacecraft buildup, qualification testing of the prototype and data analysis and reporting.

3.2.6 Test, Launch, and Flight Support

GE-RESD Engineering will provide support for both in-house and field testing. They will provide technical direction in problem solving efforts and actively support both test and launch operations.

Engineering personnel will provide around the clock support at NASA/AMES and at the Flight Control Center for seven days following launch. Following this, Engineering personnel will be available on an "on-call" basis for the remainder of the flight. On-call personnel will be located at both NASA/AMES and the designated control center.

3.3 AEROSPACE GROUND EQUIPMENT (AGE)

3.3.1 Electrical AGE

The following electrical AGE will be provided for development and test of the Bioresearch Module (Types I and II).

3.3.1.1 Mission I

3.3.1.1.1 Attitude Control Test Set

This test set will be a two-bay console to be used to verify the operation of the attitude control subsystem consisting of the following:

(1) Console Power Supply - a modular power supply which is isolated from Bioresearch Module power shall be used for console circuitry.

(2) BRM Power Supply - an adjustable voltage supply isolated from console power shall be used for the BRM.

(3) Power Control and Distribution Panel - all power, AC, Console DC or BRM DC, shall be routed through this panel with circuit breaker protection of AC power.

(4) Stimulus Generator Panel - Stimuli for the threshold detection and command generation to the attitude control electronics will originate in this panel.

(5) Monitor Panel - Output signals from attitude control electronics will be monitored with this circuitry.

(6) Sensor Stimulator Panel - Controls for the sun sensor stimulator and monitoring of its output will be accomplished with this panel.

(7) Gyro Control Panel - Self - test circuitry for gyros and monitors of the output is included in this panel.

3.3.1.1.2 TT&C Test Set

This test set will be a two-bay console used to verify operation of the TT&C subsystem consisting of the following:

(1) Console Power Supply - a modular power supply which is isolated from Bioresearch Module power will be used for console circuitry.

(2) BRM Power Supplies - adjustable modular supplies shall be used to power the TT&C subsystem. The supplies will be isolated from console power.

(3) Power Control and Distribution Panel - Power AC, Console DC and BRM DC will be routed through this panel with circuit breaker protection of AC power.

(4) Bioresearch Module Timer Panel - output times from the data handling unit shall be measured with this panel.

(5) Voltage Monitor Panel - All subsystem voltages shall be monitored on this panel.

(6) Command Generator Panel - TT&C commands will be generated in this panel and used in conjunction with QC transmitting equipment.

(7) Command Monitor Panel - Outputs from the command subsystem will be monitored with this panel.

(8) Control Panel - All TT&C controls other than commands originate in this panel.

(9) Monitor Panel - outputs from the TT&C system other than command outputs will be monitored on this panel.

3.3.1.1.3 System Test Set

This test set will be a two-bay console to be used to verify operation of the service module system consisting of the following:

(1) Console Power Supply - a modular power supply which is isolated from Bioresearch Module power shall be used for console circuitry.

(2) BRM Power Supply - an adjustable voltage power supply isolated from console power shall be used to power the service module and power controller.

(3) Power Control and Distribution Panel - Power, both AC and DC will be routed through this panel with circuit breaker protection for AC power.

(4) System Control Panel - system commands and stimuli for the service module shall originate in this panel.

(5) Power Controller Panel - the power controller shall be stimulated and its output monitored thru this panel.

(6) System Monitor Panel - outputs of the service module shall be monitored with this panel.

(7) Command Generator Panel - Commands, either hardwire or airlink will originate in this panel and be used with transmitter to command receiver of service module.

No mention has been made of recording devices for monitoring of BRM signals in any of the test sets. It is assumed that systems test recorders are to be used for all BRM testing and cables and monitor tie points from the BRM to the recorders will be designed.

All cables to the BRM interface and power sources will be designed.

3.3.1.1.4 Launch Console

This two-bay console will interface with the Wallops Island Launch Facility and will provide:

(1) Console Power Supply
(2) Bioresearch Module Power Supply
(3) Power Control and Distribution Panel
(4) System Control Panel
(5) System Monitor Panel
(6) Command Generator Panel

It is assumed that recording devices will be provided as a part of the overall launch facility.

3.3.1.1.5 Special Test Equipment

Approximately twenty "tee" boxes to monitor signals in the BRM harnesses and approximately ten test cables will be designed.

3.3.1.2 Mission II

Due to the change in the attitude control subsystem in the service module for Mission II the following changes in AGE will be provided.

3.3.1.2.1 System Test Set

The following panels will change for Mission II:

(1) System Control Panel
(2) Recorder Panel
(3) Connector Panels
(4) Cables

3.3.1.2.2 Attitude Control Test Set

The following panels will change for Mission II:

1) Stimulus Generator Panel
2) Recorder Panel
3) Cables

3.3.1.2.3 Special Test Equipment

Approximately six "tee" boxes and six test cables will change due to Mission II changes.

3.3.2 Mechanical AGE

The following mechanical AGE will be provided for development testing, qualification and flight acceptance of the prototype Bioresearch Module (BRM):

(1) BRM Assembly Checkout Stand - to be used for supporting the BRM during system testing.

(2) Solar Panel Deployment Checkout Stand - to be used to position the BRM during actuation of individual panels to determine proper deployment.

(3) Thermal Control Unit - to be used to provide ground cooling to the cold plate.

(4) A/C Pneumatic Checkout Units - used for proof pressure, leak check and service of the BRM.

(5) Mass Spectrometer - to be used to establish pressure integrity of the pneumatic subsystem.

(6) Experiment Installation Equipment - special tools required to install the experiment module.

(7) Solar Panel Installation Equipment - special tools required for installation of solar panels.

(8) Hydrasets - This plan assumes the availability of the Hydrasets from the Biosatellite program.

(9) Slings - to pick up, move and position the BRM and BRM sections.

(10) Bioresearch Module Shipping Container - required for shipping the BRM to a remote acceleration test facility.

(11) Solar Panel Shpping Container - required for shipping solar panels to a remote acceleration test facility.

(12) Sun Sensor Stimulator - used for stimulating the sun sensors.

(13) Attitude Control Alignment Equipment - used for alignment checks of nozzles, rate gyros, sun sensors, deployable rods and momentum package.

(14) Relief Valve Panel - safety device to provide relief valve capability under all conditions of pneumatic test.

(15) Module Handling Equipment - for TT&C, A/C and EP&D modules.

The following software and support tasks will be performed as part of the AGE effort:

- Provide Launch Site Facilities Specification in conjunction with Mechanical AGE personnel.
- Support in-house testing effort.
- Support design reviews on Bioresearch Module and AGE.
- Provide technical assistance on special problem solving team efforts.
- Provide necessary operations and maintenance documentation on Electrical AGE End Items.

- Support range and in-house safety requirements effort.
- Provide subsystem support to program office documentation and coordination efforts, including customer interface and direction meetings.
- Provide technical monitoring of subcontract efforts associated with AGE.

4.0 OPERATIONS PLANNING

4.1 SUMMARY

Operations planning will be conducted in two phases; (1) a general phase to be performed as part of the prototype development program and (2) a mission specific phase to be performed for each mission. The general operations planning conducted in parallel with the prototype Bioresearch Module design and development will assure compatibility between the BRM and the operational facilities. In addition, the effort will define all long lead time operational requirements in sufficient time to assure the availability of the necessary facilities for launch. The mission specific operations plans will result in the generation of supplementary plans required to integrate specific experiment operational requirements into the general plans.

4.2 LAUNCH OPERATIONS

Launch operations will be conducted from Wallops Island. The launch operations documentation will be directed toward the Wallops requirements.

4.2.1 Mission Working Group

A Mission Working Group will be established and charged with the responsibility for the direction of all documentation efforts, the physical integration program, the operational integration program and is, in general, charged with mission responsibility on the working level. GE as the Bioresearch Module contractor, will provide representation in the Mission Working Group and will furnish the group with Bioresearch Module technical data and operational requirements information as required.

The first meeting of the Mission Working Group should be convened no later than 12 months before completion of Type I mission Systems Qualification.

4.2.2 Payload Description Document (PDD)

For a launch from Wallops, the range and vehicle documentation requirements have been combined into one common document called the Payload Description Document. Format of the document will be as defined in the Scout User's Manual.

4.2.3 Range Safety Compliance Plan

A Range Safety Compliance Plan and supporting technical data will be prepared in order to satisfy Wallops Island range safety requirements.

4.2.4 Launch Site Facility Specification (LSFS)

A detailed specification for launch site facilities requirements will be issued as a supplement to the PDD. The document will define specific interface information such as AGE power requirements, cable routing, etc. for the facilities to be used by GE at the launch site.

4.2.5 Compatibility Test Plan

A Compatibility Test Plan will be prepared for the Scout. The plan will specify the procedures to be used for conducting the BRM-launch vehicle compatibility tests.

4.2.6 Countdown Manual Inputs

Countdown Manual inputs are considered mission specific since detailed countdown procedures will depend, to a large extent, on mission specific experiment requirements. GE will furnish general countdown information through the Mission Working Group; however, detailed countdown documents will be prepared on a mission-by-mission basis.

4.3 FLIGHT OPERATIONS

4.3.1 Bioresearch Module Measurement and Command Lists

The Bioresearch Module measurement and command lists will be expanded and published at about 12 months before the end of Type I mission System Qualification. The lists will be maintained throughout the life of the Program.

4.3.2 Mission Profiles

A Mission Profile will be prepared for each of the two mission types. The Profiles will contain launch and orbit parameters and a listing of key mission events versus time from terminal countdown through launch and orbital flight.

4.3.3 Tracking and Data System Interface Control Document (T&DS ICD)

The T&DS ICD will define the Bioresearch Module-ground system interfaces, including margin calculations for each communication link and a definition of formats for the handling of data within the system. The document will serve as the basic data format control book for the Bioresearch Program.

4.3.4 Support Instrumentation Requirements Document (SIRD) Inputs

The SIRD is the official document used by the Bioresearch Project to levy requirements on the Operational Support Agency. GE, as Bioresearch Module Contractor, will prepare the BRM portions of the SIRD for approval and publication by NASA/ARC. The required information will be provided on standard SIRD format pages.

4.3.5 Bioresearch Module-Ground System Compatibility

A Bioresearch Module-ground system compatibility test will be conducted as part of the prototype development program. The test will be run at a NASA center using engineering development hardware provided by GE. A Compatibility Test Plan will be prepared by GE two months prior to running the test.

4.3.6 POCC Facility Specification

The POCC Facility Specification will supplement the SIRD by providing a detailed definition of requirements for POCC facility configuration, status displays, voice communications, etc.

4.3.7 POCC Computer Program Requirements

The POCC Computer Program Requirements will supplement the SIRD by specifying, in detail, the requirements for mission dependent software for the POCC. The requirements will include a definition of inputs and input formats; outputs and output formats; algorithms to be used; and a detailed listing of the system data base.

4.3.8 POCC Operations and Procedures Manual

The POCC Operations and Procedures Manual will contain a description of the POCC facilities, computer processing capabilities and operating procedures. The document will serve as (1) an orientation aid for all personnel who will participate in Bioresearch operations, and (2) a ready reference job aid that can be used by support personnel during mission operations.

4.3.9 Technical Reference Manual

The Technical Reference Manual will consist of a comprehensive functional description of the BRM hardware, sensor calibration curves, command definition and other reference data required for evaluation of BRM performance.

4.3.10 Mission-Specific Documents

Certain documents required for flight operations will be prepared on a mission-by-mission basis since they will contain information that is experiment and/or BRM specific:

(1) Detailed On-orbit Operating Plan
(2) Experiment Measurement and Command Lists
(3) Mission Exercise Plan
(4) Calibration Book
(5) Flight Evaluation Report

In addition, the basic operations documents prepared during the development program may require updating by means of addenda in order to integrate any unique experiment operation requirements on a mission-by-mission basis.

5.0 CONFIGURATION MANAGEMENT

GE-RESD will establish a Configuration Management Program for the Bioresearch Program. The program will define the requirements for the preparation, issuance, revision, approval, distribution and control of all engineering design documentation. A Configuration Management Plan will be prepared after program go-ahead and will be submitted to NASA/ARC 90 days after contract award.

Configuration Management at GE-RESD is recognized as a vital and integrated part of program management practices. Configuration Management, as a concept and discipline at GE-RESD, has evolved over a number of NASA Re-Entry Vehicle System and Air Force Missile Weapon Systems. Configuration Management at GE-RESD has kept pace with current concepts, progressing from design change control to management and control of the complete configuration or technical documentation.

The concept of the GE-RESD Configuration Management System is a realization that technical documentation is a product of design and supporting technologies, as hardware is a product of manufacturing. For effective performance, both must be controlled, and the approved configuration is the baseline for each. The baselines which will be used on this program are:

(1) Preliminary Design Review (PDR)
(2) Critical Design Review (CDR)
(3) Acceptance Verification

These baselines will serve as engineering reference points which represent the progressive and evolutionary development of the engineering documentation.

A Configuration Management Engineer will be assigned to the Bioresearch Program as is done for each program in GE-RESD. His background is engineering and his specialty is Configuration Management. He will be the authorized representative of the GE-RESD Program Manager on all matters related to the approval or disapproval of internal design changes, control of the configuration/technical documentation prepared by GE-RESD for NASA/ARC, identification of end items through the technical requirements, specifications, drawings and definition reports, and configuration accounting of change implementation status. He will be responsible for:

(1) Providing the response for proposals on customer requirements for Configuration Management.

(2) Developing the Configuration Management System and providing the Configuration Management Plan.

(3) Issuing procedures and conducting administrative audits.

(4) Providing Configuration Identification information; issuing Configuration Definition Listings.

(5) Establishing a Design Change Board for internal configuration control; integrating and approving all design changes, waivers and deviations.

(6) Preparing Engineering Change Proposals (ECP's) per ANA Bulletin No. 445 for customer approval of Class I changes. (Flight Program)

(7) Monitoring implementation of contract integration requirements for interface documentation of the Scout launch vehicle and the government furnished payload package.

(8) Reporting the configuration implementation status.

The Configuration Management System at GE-RESD meets the intent of NPC 500-1 by embodying a formal uniform method of Configuration Identification, Control and Accounting. (See Figure II.5-1 for outline of GE-RESD's Configuration Management System). Since this is an established but flexible procedure of doing business at GE, it will mean minimum cost to the NASA/ARC Bioresearch Program. Data and documentation will be utilized for this program only to the extent of insuring program objectives. This Configuration Management System has been used over the past several years on many programs including NASA's Biosatellite Program and the Air Force's Minuteman III Programs.

5.1 CONFIGURATION IDENTIFICATION

The Configuration Identification phase of the system is the technical documentation of the approved configuration. This includes definition of design requirements which lead to documentation of specifications for the program. The baseline concept will permit an orderly transition from one control point to the next so that effective communications will be achieved in the development of the program. This is extremely important for the Bioresearch Program because of its experimental nature which will require close scrutiny of design effort, interfaces and reliability for retrieval of data. Accurate definition will be an absolute necessity in order to insure correct interpretation of the experimental test data.

5.2 CONFIGURATION CONTROL

Once a design document is complete and forms part of a baseline, it will be subject to the functions of Configuration Control which will enable engineering and program management to accomplish decisions affecting design trade-offs and other program considerations involving schedule and cost.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

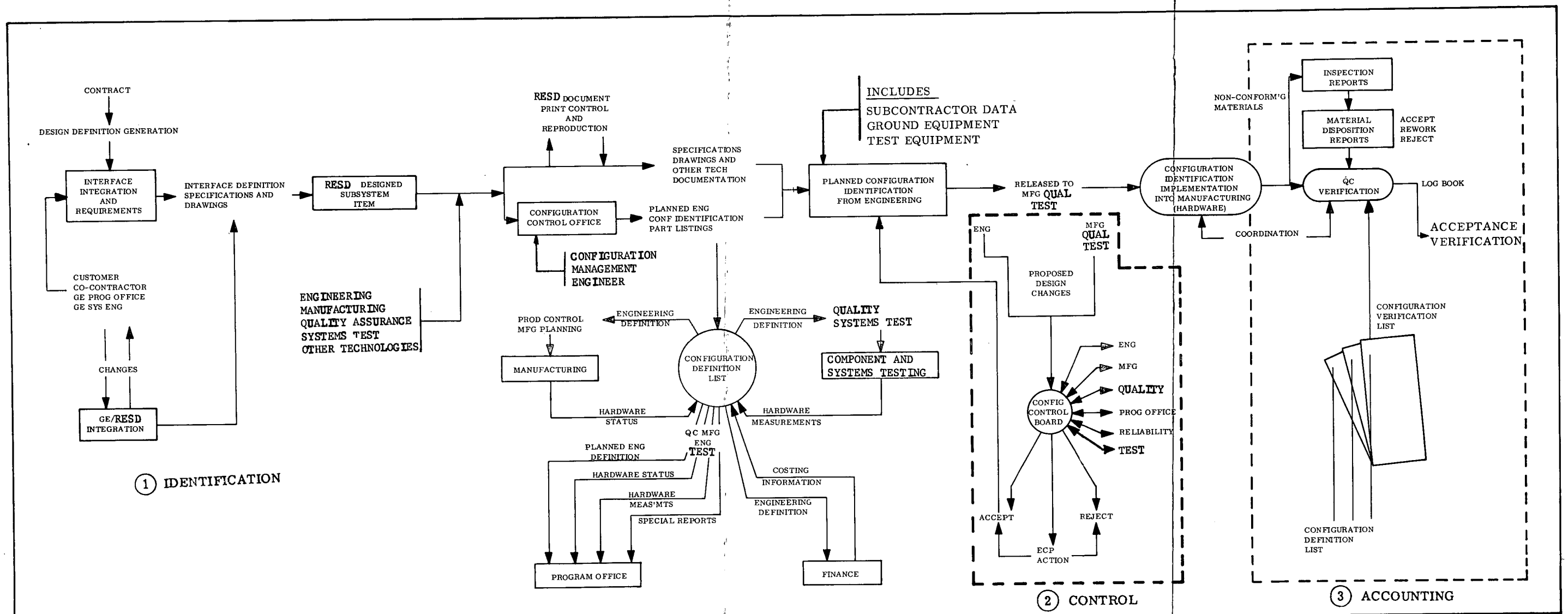

Figure II.5-1. GE-RESD's Configuration Management System

The Bioresearch Design Change Board (DCB) will be chaired by the Configuration Management Engineer who will represent the Bioresearch Program Office. To keep the design cycle as short as possible, the Design Change Board will meet daily. During the meetings, the Board will review, integrate and evaluate all proposed changes to design documents. Representatives from various disciplines will be assigned to this Board. All approved changes will be fully documented in order to maintain a high level of design definition.

All design changes shall be classified as Class I or Class II, as defined by ANA Bulletin 445, as is ordinarily done in GE-RESD. It will be the responsibility of the Bioresearch Design Change Board to review the classification and to make certain the change is properly classified prior to approval and release. All changes proposed for drawings and specifications (performance or design) will be documented on the Alteration Notice form (See Figure II.5-2).

5.3 CONFIGURATION ACCOUNTING

The status of the current configuration on any end item and its location is essential for management in order to maintain traceability and determine compatibility of technical documentation. This will be accomplished by Configuration Accounting, which is the measurement of hardware against planned engineering documentation and the reporting and documenting of changes and non-conformances to the baseline configuration. The important phases of this procedure are the preliminary and critical design reviews, and acceptance verification.

A Configuration Verification List for each end item will be prepared which shows the planned engineering identification and the differences which occurred for a serial

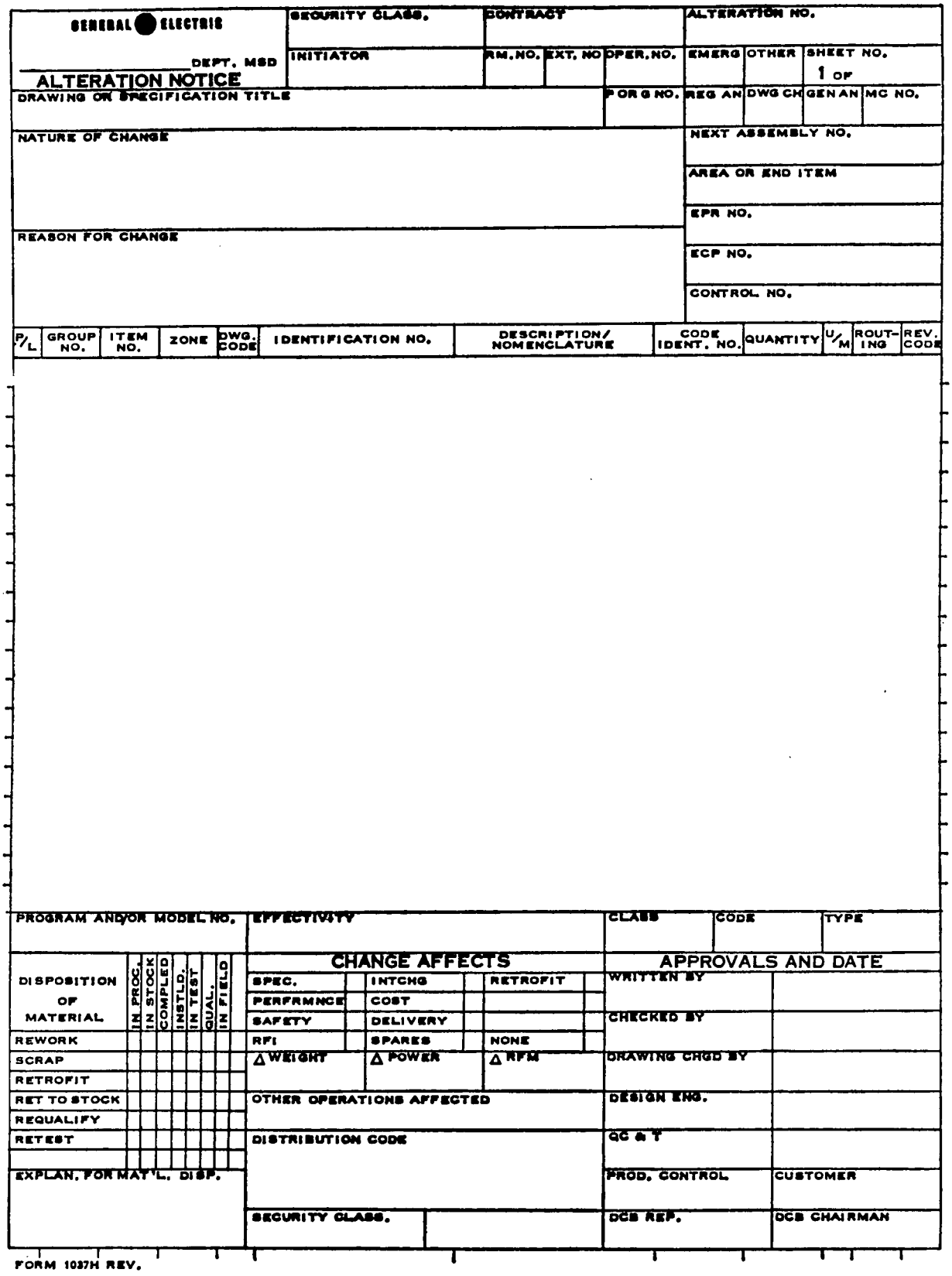

Figure II.5-2. Alteration Notice

numbered end item. The listing will be incorporated in the Customer Logbook along with specific supporting test results and proof documentation for any discrepancy against the Configuration Definition.

5.4 ENGINEERING PARTS LIST

The Engineering Parts List and related data will be accumulated into a format so that it can be integrated into a master record through mechanization. The Configuration Definition List, which is the result, will be defined to the lowest level for each serial number of each end item of hardware including the drawing revision letters for the outstanding changes which have been generated. The list is a part of the standard procedure for the Configuration Management System. It will be used as the planned Engineering Configuration Definition by all the GE-RESD operations. A second list, in drawing number sequence, will also be generated. These lists will show any and all configuration differences including all hardware differences between spacecraft.

They will be compiled, revised, updated and distributed to Engineering, Quality Control, Manufacturing, System Test and the Program Office on a scheduled basis. This will be accomplished through a Mechanized Data System for the accumulation, storage, sorting and dissemination of the data.

A baseline configuration for all Contract End Items will be established at the Critical Design Review (CDR). The Configuration Definition List will define and continuously update the baseline configuration incorporating all approved changes. The configuration definition of the Contract End Items is to be the basis for hardware definition and acceptance verification.

5.5 ENGINEERING DRAWINGS

The standardization and control of design practices and processing procedures is considered to be a major element affecting the performance of a product. All drawings will be prepared in accordance with Specification MIL-D-1000, Form 2, and MIL-STD-100. These instructions are to be supplemented by GE-RESD Drafting Practices Manual 702 which meets the requirements of the Military specifications. In order to assure uniformity in drafting practices, periodic audits will be conducted by the Configuration Management Office. The results of these audits will be provided to the responsible Design Operation Managers for corrective action. Consultation on the application and interpretation of drawing requirements and the indoctrination of new personnel in GE-RESD design practices will be provided. GE-RESD will review the Drafting Practices of all Suppliers and Subcontractors for compliance and compatibility. After the end items in the program are identified and specifications defining the requirements which must be met by each are prepared, detail work by Engineering will begin in order to develop drawings and detail specifications from which hardware can be made.

The Early Release (ER) procedure will be used in the fabrication and test of the Systems Development Spacecraft. This procedure is used when engineering information is released early in a program so that the affected operations within the Division will have information for functions which must proceed concurrently with the development of the engineering solution. The procedure allows the engineer maximum freedom in making changes without formal change control, yet it provides a means of retrieving change information and recording it in an organized and uniform manner. The preliminary status of the drawing and/or specification is signified by the capital letters "ER" in front of the identification number of the document. The documents will contain all the information necessary to accomplish their intended use, and the amount of information and tolerances used will also be determined. When the design criteria of a released document is completed, the "ER" prefix is removed from the identifying number of the document and the document is issued as completed. It is then subject to the formal requirements of Design Change Control Procedure.

The symbols assigned to a change affecting hardware are in alphabetical sequence and those assigned to format changes are in a numerical sequence. In this way, a simple scanning of the revision block is all that is necessary to determine the action required by that user. The revision letter is advanced only when the change actually affects hardware. The system will permit identifying hardware through marking to correspond exactly to the drawing revision to which it was made. Once a design change is approved, advance copies of the approved Alteration Notice are distributed to Design Engineering, Production Control, Quality Control and Systems Test Operations, so that incorporation of the change into hardware can then take place.

5.6 INTERFACE DEFINITION AND CONTROL

GE-RESD, as Bioresearch Module contractor, will perform liaison and provide information to the associate contractors to enable establishment of interface criteria and completion of program objectives, and will identify conflicting requirements. Required effort will be made by GE-RESD to resolve any problem areas and to assure compatibility of the BRM with the launch vehicle and with the experiment package.

Interface Control Drawings will be prepared in accordance with GE-RESD Drafting Practices 702 which are company standard procedures and which meet the requirements of Specifications MIL-D-1000, Form 2, and MIL-STD-100. These drawings will show documentation of interface design and agreements on space allocation for hardware. All dimensions will be referred to common line and/or planes that can be readily and accurately established. A tabulation of these drawings, which will be under formal design change control procedures, will be maintained by the GE-RESD Configuration Management Office. This tabulation will be a definition listing which will be updated periodically to reflect revisions of drawings as any changes are made.

6.0 MANUFACTURING PLAN

The purpose of the Manufacturing Plan is to define the steps necessary to produce (by fabrication or procurement) those items necessary to support the Bioresearch Module Program.

6.1 BUY COMPONENTS

A typical plan for procuring buy components is shown in Figure 11.6-1. Preliminary plans now call for procurement of the following listed components:

Rate Gyro	Receiver
Sun Sensor	Latching Valve
Momentum Wheel (Type I)	Regulator
Deployable Rods (Type II)	Solenoid Valve
Transmitter	High Pressure Transducer
Data Storage Unit	Low Pressure Transducer
Hybrid	Pressure Tank
Diplexer	Pneumatic Filter
Coax Switch	Battery
Decoder	Guillotine

6.2 MAKE COMPONENTS

A typical plan for fabricating in-house components is shown in Figure II.6-2. This flow is typical for the fabrication of components designated for qualification, flight, spares, or the prototype BRM. The components fabricated for systems development would follow this flow except they will be produced using the Early Release (ER) Drawing System.

6.3 SOLAR PANELS

The Solar Panel Fabrication Plan is shown in Figure II.6-3. This plan shows fabrication of the honeycomb solar panel structure followed by shipment of these panels to a supplier for installation and check out of solar cells. Eight solar panels will be fabricated for structural development with cells installed at selected locations and the remainder of the cells being mass simulated. Two prime panel assemblies will be fabricated for panel qualification. Two prime panel assemblies will be fabricated for usage on the prototype spacecraft.

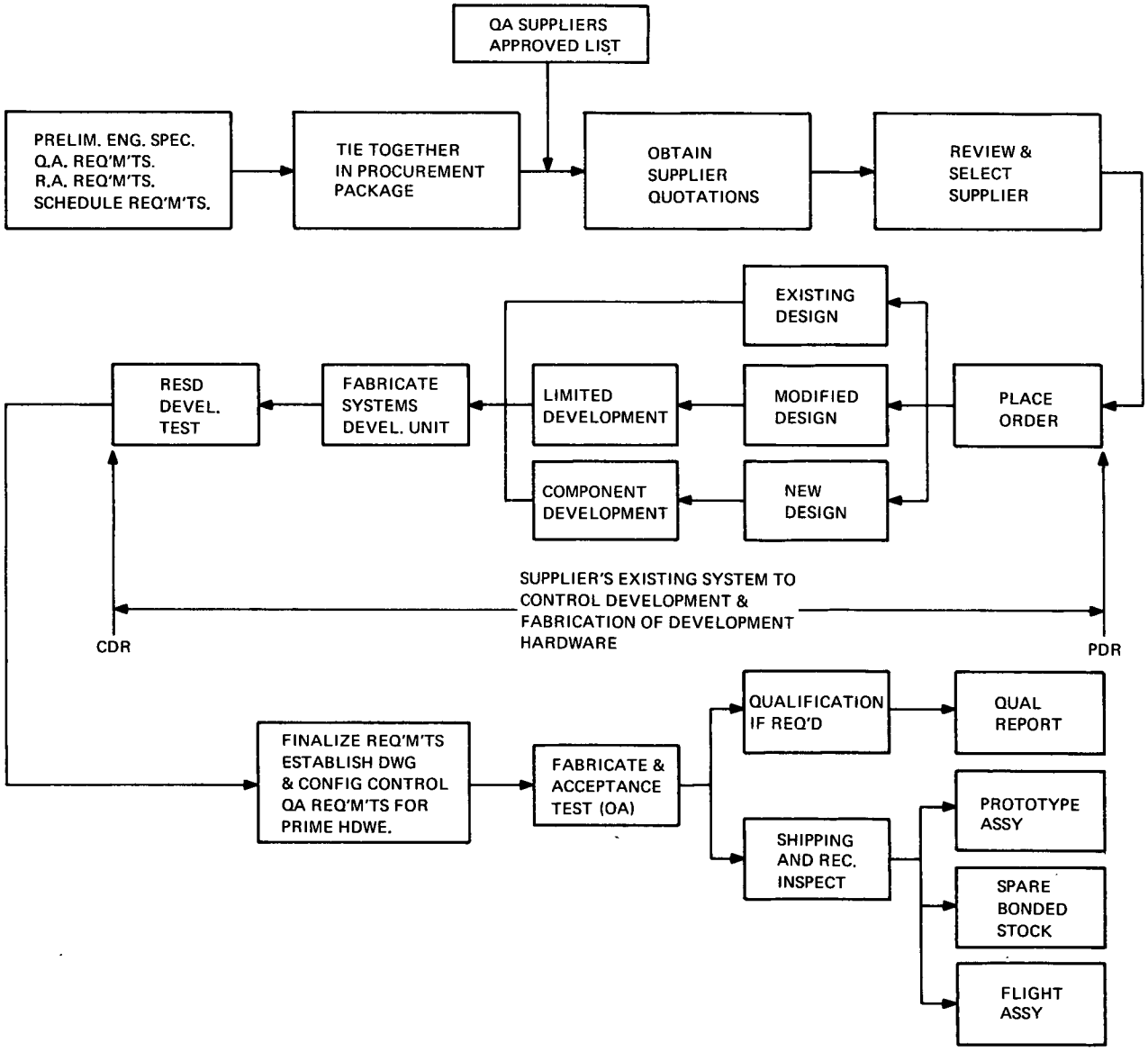

Figure II.6-1. Typical Buy Component Plan

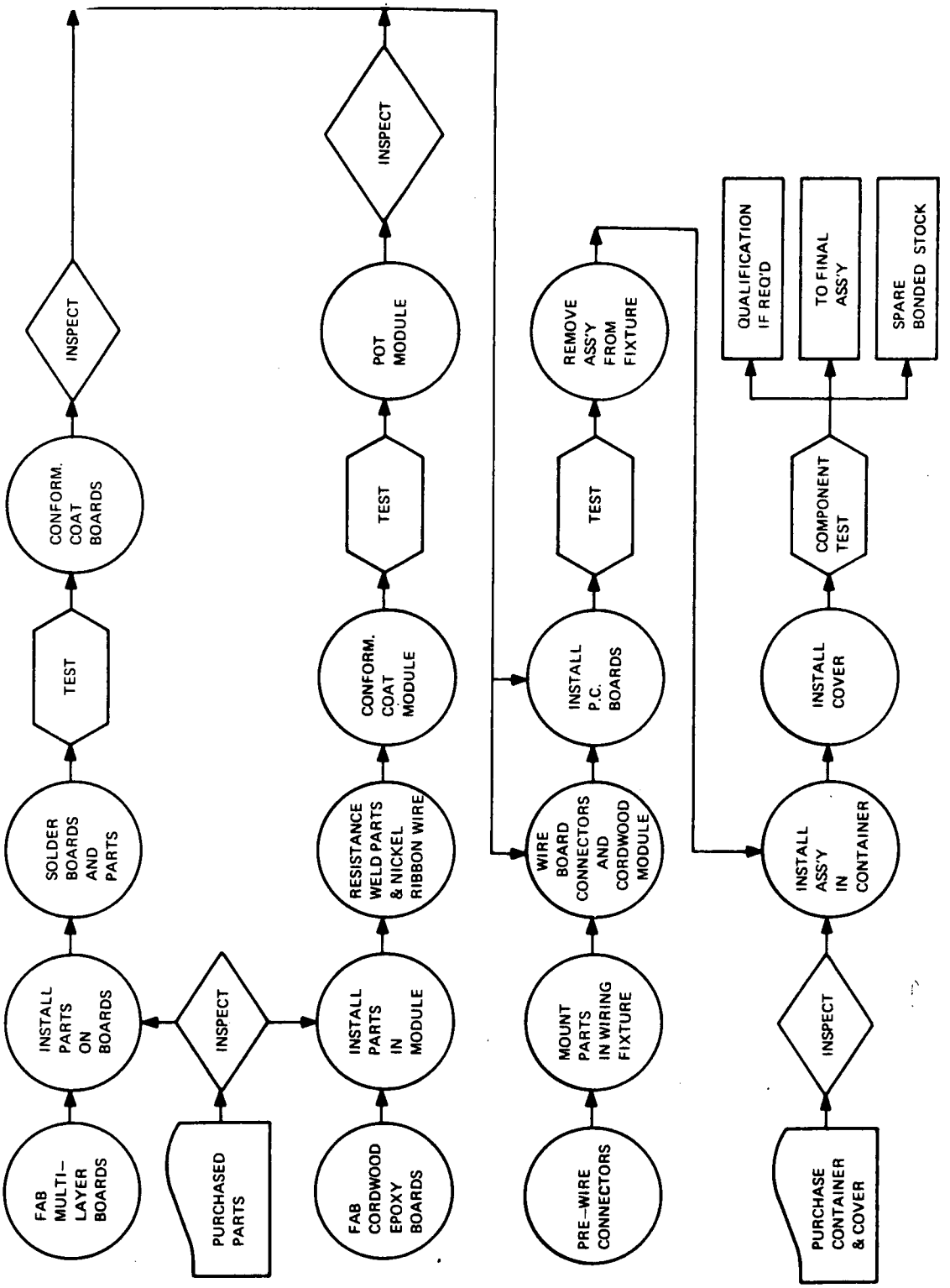

Figure II.6-2. Typical Make Component Plan

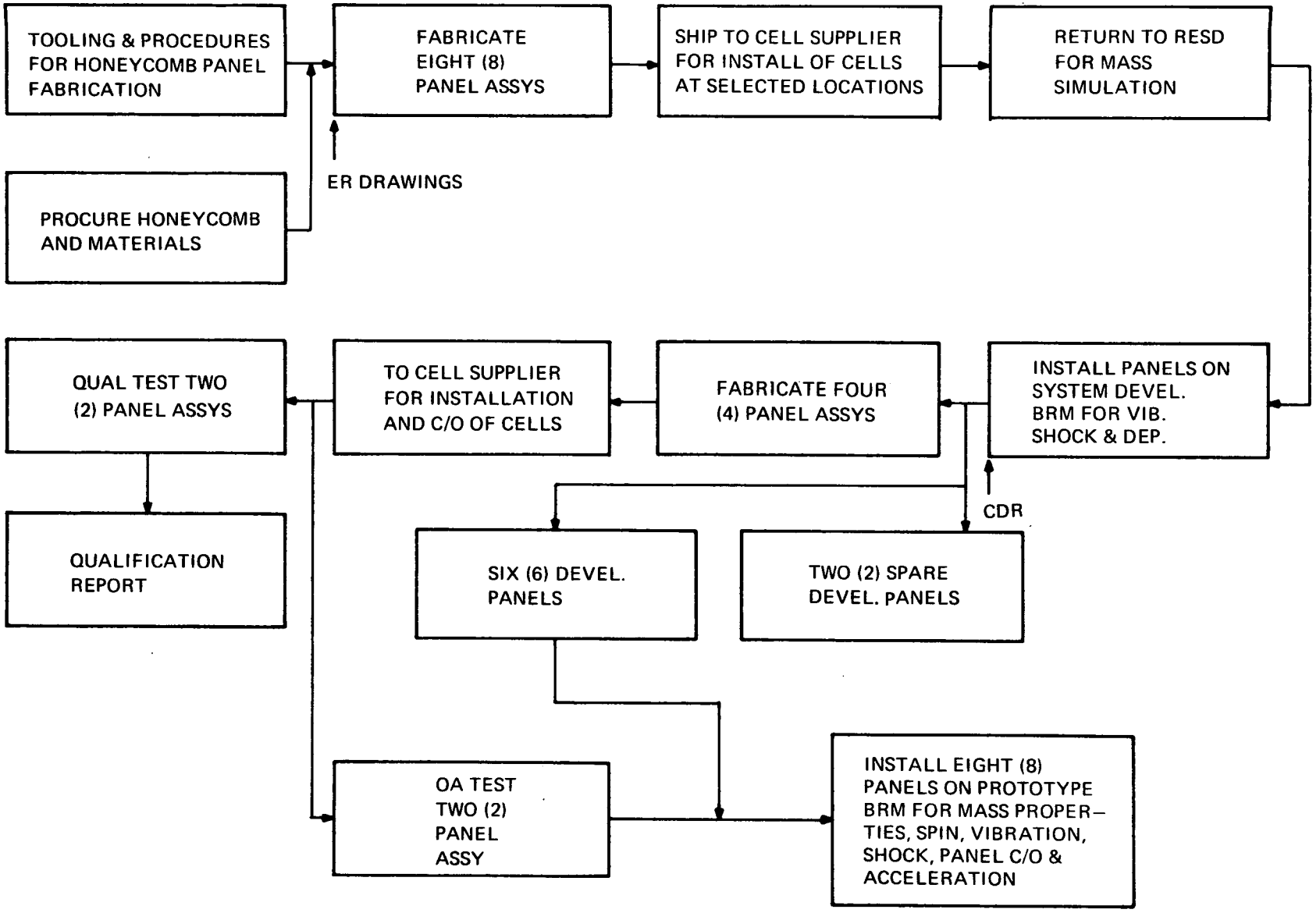

Figure II.6-3. Solar Panel Fabrication Plan

6.4 SYSTEM DEVELOPMENT BIORESEARCH MODULE

The System Development Bioresearch Module Plan is shown in Figure II.6-4. This BRM will be fabricated to Early Release Drawings.

The basic structure with dummy components will be fabricated for structural development tests. Following these test this structure will be used for electrical systems development. The subsystem development test modules will be installed plus system development harness.

6.5 PROTOTYPE AND FLIGHT BIORESEARCH MODULE

The prototype and flight fabrication plan is shown in Figure II.6-5. These BRM's will be fabricated to released/final design requirements.

6.6 TYPE II ATTITUDE CONTROL MODULE

The fabrication plan is shown in Figure II.6-6. This module will be fabricated to released/final design requirements.

7.0 BIORESEARCH MODULE INTEGRATED TEST PROGRAM PLAN

7.1 INTRODUCTION

GE-RESD will provide an Integrated Test Program Plan three (3) months after contract receipt. This plan will describe a comprehensive program of testing directed and conducted by GE-RESD and its suppliers to develop, evaluate, qualify, and fly the Bioresearch Module, Mission Types I and II. The overall plan will be in accordance with Figure II.7-1 (development) and Figures II.7-2 and II.7-3 (flight).

The basic purposes of the test program are as follows:

1) Provide a high degree of confidence that the Bioresearch Module will survive the environments imposed during the mission sequence from fabrication through completion of the mission.

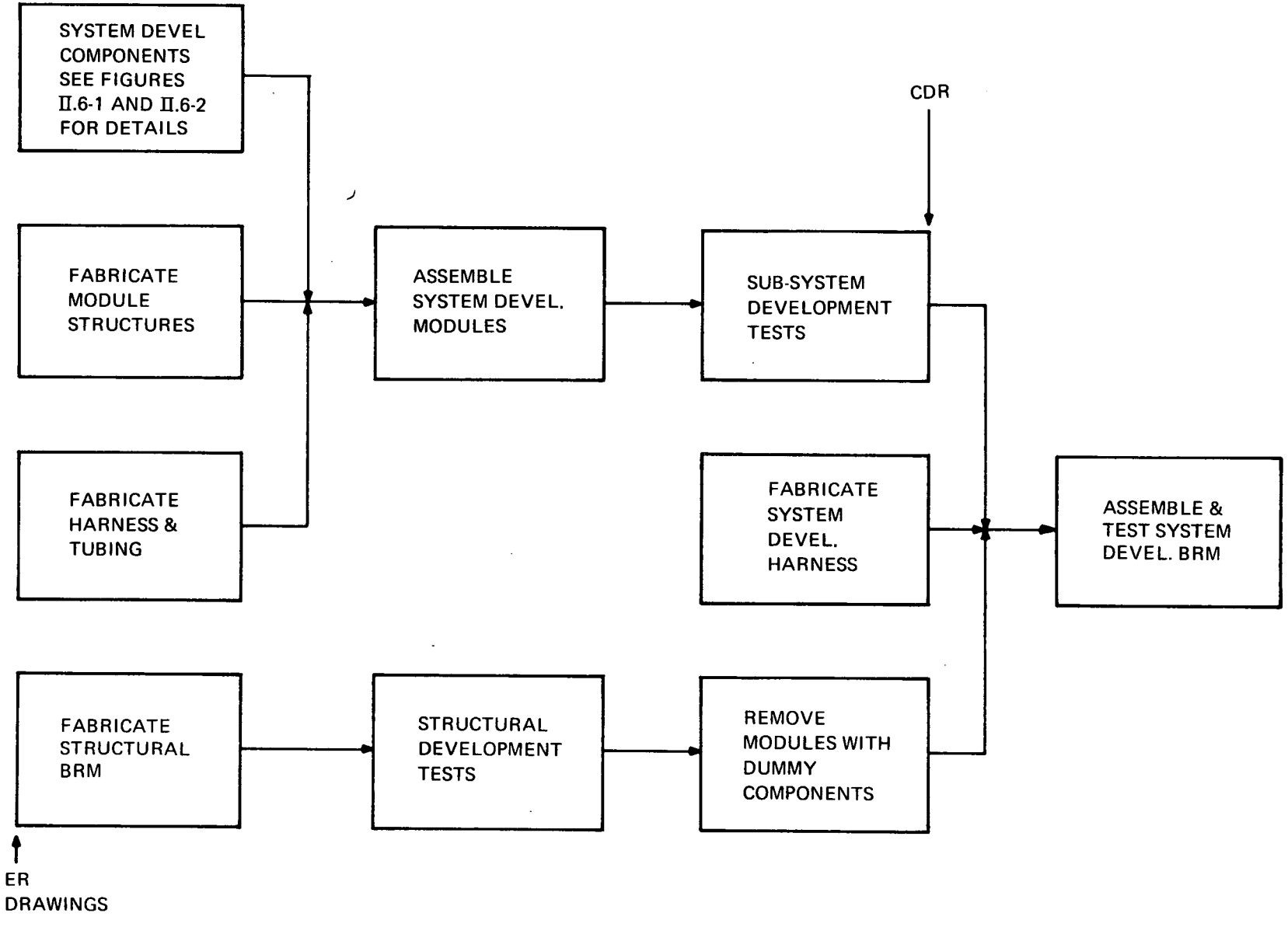

Figure II.6-4. System Development Fabrication Plan

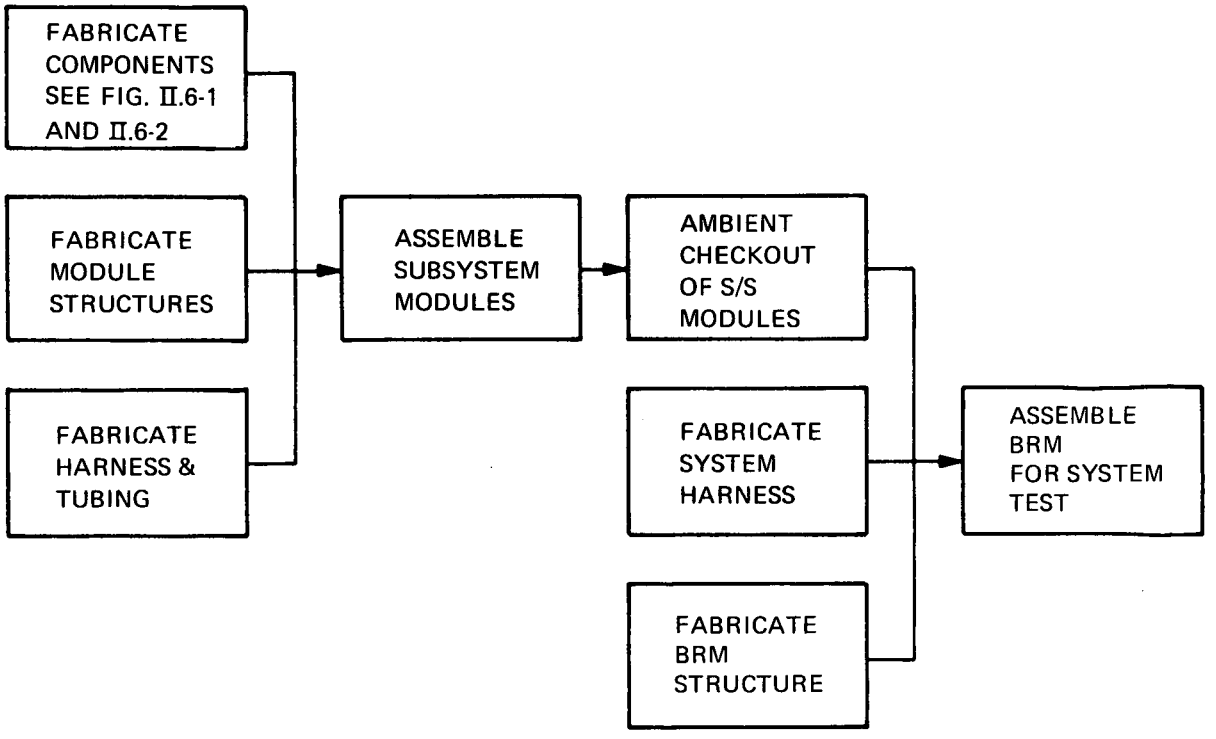

Figure II.6-5. Prototype and Flight Bioresearch Modules

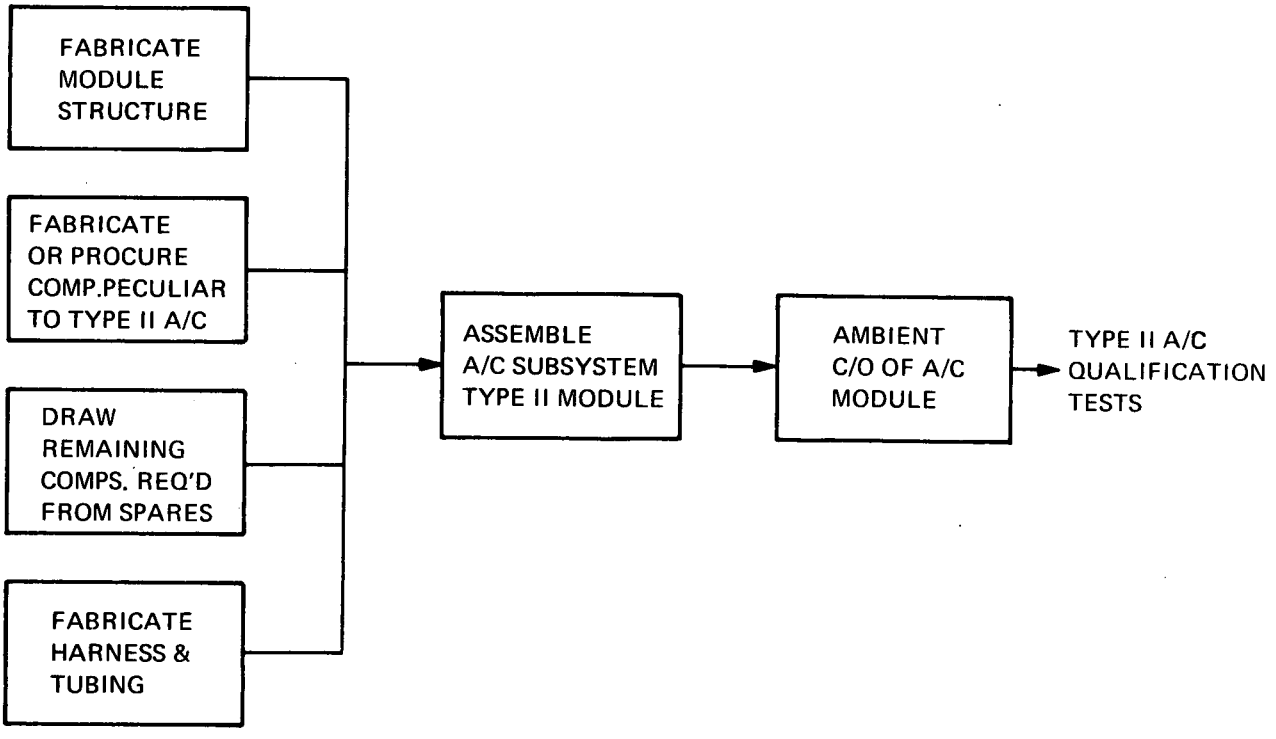

Figure II.6-6. Type II Attitude Control Module

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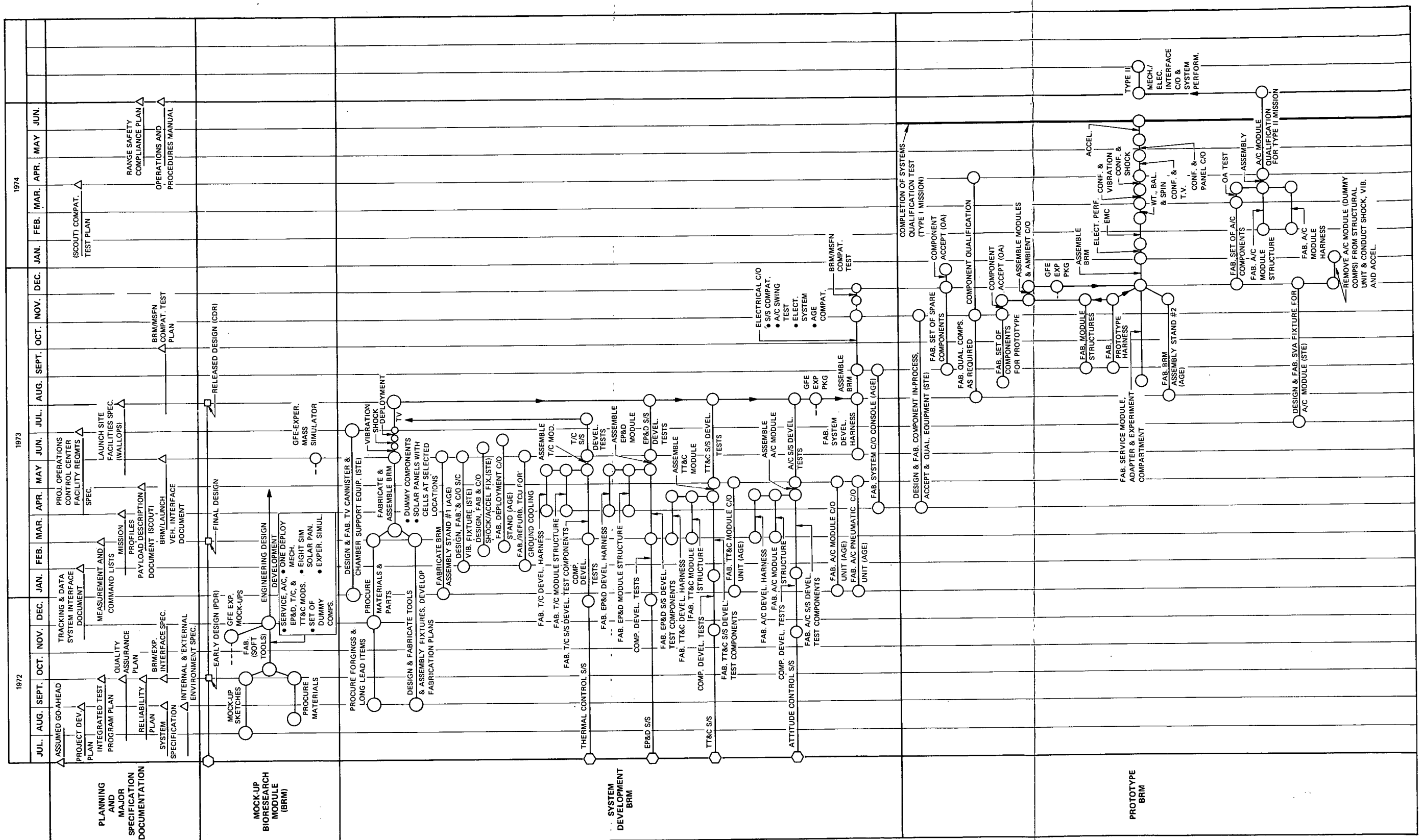

Figure II.7-1. Bioresearch Module Development Program Schedule

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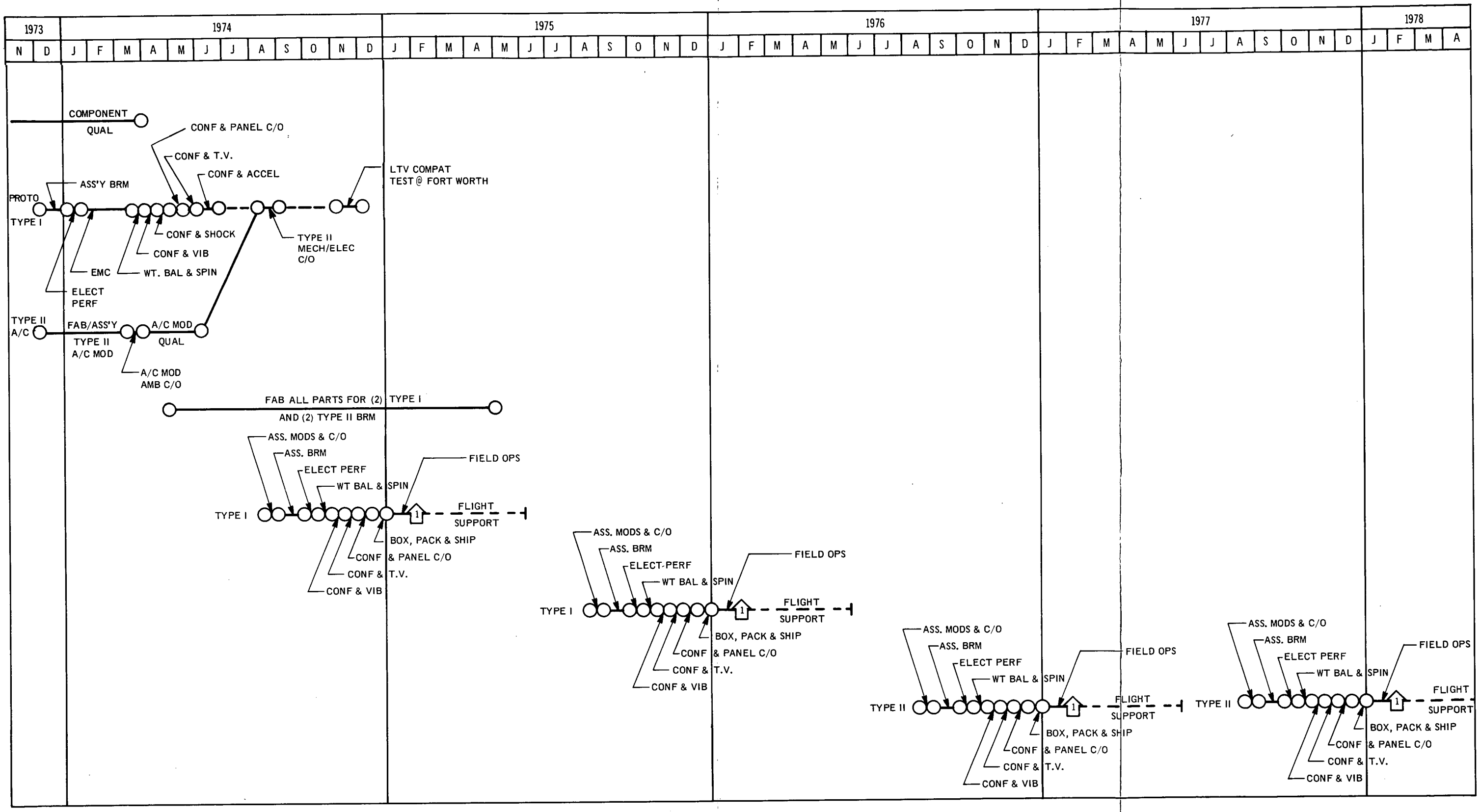

Figure II.7-2. Option I - Prototype +4 Flight Bioresearch Modules

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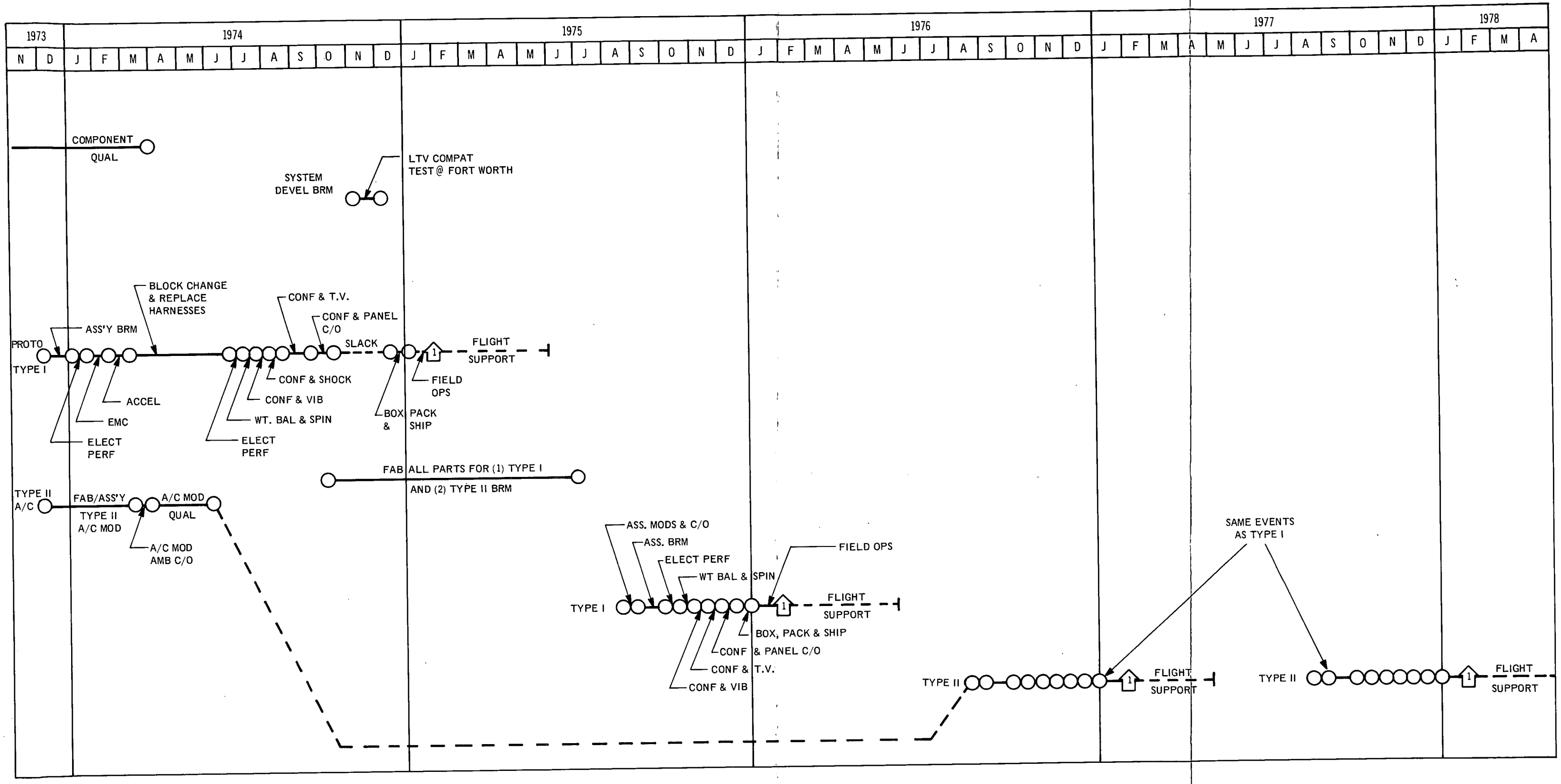

Figure II.7-3. Option II ~ Protoflight +3 Flight Bioresearch Modules

2) Assure quality hardware which will successfully perform its intended mission.

3) Determine BRM operating and performance characteristics from simulated mission and environmental testing.

4) Obtain BRM evaluation data in order to enhance the achievement of the Bioresearch Module Missions.

It is noted that tests added or deleted will be considered as being subject to discussion and negotiations, if necessary, between GE-RESD and the contracting agency.

7.2 GENERAL INFORMATION

The necessary test definitions, hardware definitions, definition of terms, and information which will aid in fully understanding the discussions included in this document are as follows:

7.2.1 Test Definitions

7.2.1.1 Engineering Design Development Tests

Engineering Design Development Tests are those tests performed at the component, subsystem and system levels to evaluate performance, to determine capability of each part with the whole and to ascertain the adequacy of the design to meet specified requirements.

7.2.1.2 Qualification Tests

Qualification Tests are performed to demonstrate that the design is inherently capable of meeting the established requirements. In these tests, the qualification prototype items are subjected to environmental rigors more stringent than those expected from transportation, handling, storage, launching and orbital flight to determine margins in excess of flight requirements.

(1) Electronic Piece Parts which have been qualified for other programs under conditions adequate for the Bioresearch Module will not require requalification. Electronic piece parts that have not been previously qualified under applicable conditions shall be qualified.

Existing components that have been previously designed and fabricated for other similar programs, but contain some unqualified electronic piece parts shall not require redesign to incorporate only qualified piece parts, nor shall qualification tests of these piece parts be required. Component qualification tests will be considered acceptable to qualify these piece parts.

NASA Documents listed as follows will be used in the selection of electronic parts, devices and associated materials for electronic equipment to be designed specifically for the Bioresearch Program:

AHB-5328-1 - Preferred Parts & Materials List

AHB-5328-3 - Screening Inspection for Electronic Parts

ARC-9 - Part/Device/Material Request

ARC-23 - Project Parts, Devices and Materials List

(2) Components which have been qualified for other programs under environmental conditions and stress levels compatible with the Bioresearch Mission will not require requalification. Components that have not been previously qualified under acceptable conditions shall be qualified at the component level.

7.2.1.3 Prototype Qualification Tests

Prototype Qualification Tests are those final tests performed to demonstrate performance, compatibility, and design adequacy of the system to meet mission requirements.

7.2.1.4 Acceptance Tests

Acceptance Tests are to ascertain that an item of flight hardware meets specified environmental and performance criteria established to confirm that the specimen in question is flightworthy. Acceptance tests are conducted at the component, subsystem or system level on specimens of hardware which have not been previously subjected

to serve test or handling treatments, but which are identical to the qualification test specimens in all physical respects and in the methods and controls used in their fabrication.

7.2.2 Hardware Definitions

7.2.2.1 Breadboard

Breadboard is a combination of parts or components which will essentially function as a component, subsystem or system.

7.2.2.2 Engineering Development Hardware

Engineering Development Hardware are items fabricated to specifications which are not necessarily final release specifications (Early Release System).

7.2.2.3 Qualification Prototype Hardware

Qualification Prototype Hardware are items fabricated to final release specifications, under Quality Assurance Cognizance, which may be used for tests in excess of flight levels. These items are identical to flight hardware, but may not be used for flight due to level of testing to which they will have been exposed.

7.2.2.4 Flight Hardware

Flight Hardware are items fabricated to final release specifications under Quality Assurance Cognizance, which will comprise the flight spacecraft or spares inventory.

7.2.3 Review Boards

7.2.3.1 Integrated Test Program Board

The Integrated Test Program Board (ITPB) is organized to have cognizance over all qualification testing. This board will be responsible for qualification of equipment by:

(1) Review of qualification specifications to determine agreement of the testing requirements with program requirements, and to approve such documents as valid bases for qualification.

(2) Review of requests for waivers of, or deviations from, specification test requirements.

(3) Review of data developed in qualification, confer or withhold qualification based on such reviews and issue a formal Qualification Compliance Report. Removal of qualified status when necessary due to results of later tests of the qualified equipment.

(4) Review of failure reports, failure analyses, and design changes for their effects on the qualification status of equipment.

(5) Issue official qualification status reports.

(6) Whenever a specification is not approved, or when qualification is rescinded, the ITPB defines the deficiencies in writing through the chairman and furnishes definite, precise requirements directed toward achieving qualified status.

7.2.4 Failure Procedure (Acceptance and Qualification)

In the event of anomaly or failure during acceptance testing, the standard GE Failure Reporting and action procedure will be followed. The corrective action taken and the required retest are determined by the failure analysis. Examples of anomaly/failure situations and resultant test actions are given below.

(1) An anomaly or failure which occurs during the first performance test of the first environment test would result in a fix on the specified equipment by the necessary action. The complete acceptance test would then be rerun.

(2) If a failure is precipitated by a known cause during one of the later environment tests, a fix is made and the uncompleted portions of the acceptance test are completed. If failure analysis so indicates, the completed portions of the acceptance test are rerun.

(3) If a failure is considered to be an "infant mortality" of a part, all parts of that type undergo burn-in followed by acceptance testing.

7.3 COMPONENT TESTING

Before any component can be used on the Bioresearch Module, it must have passed workmanship tests, acceptance tests, and a representative sample of the component must have passed design margin testing; the qualification tests. Component testing will be accomplished during the several program phases to assure that all components meet the environmental and performance criteria imposed by the Bioresearch Program. The testing to be performed (development, qualification, and acceptance) is described in this section.

7.3.1 Developmental Testing

Development testing will be performed during the design phase to verify that all components will meet the structural and electric/electronic requirements imposed by their specific missions. Prior to final release of a component design, development testing will be performed to assure that the component is compatible with other subsystem components. The ITPP will contain detailed information concerning component development tests requirements.

7.3.2 Qualification Testing

During qualification testing, representative (prime) components will be subjected to sequential tests in environments which are more severe than those expected during the Bioresearch missions. The purpose of qualification testing is to demonstrate that the design, method of manufacture, and inspection and test produce components which meet program requirements; and to demonstrate that design margins are adequate.

Qualification status may also be established by presenting evidence of qualification achieved on other programs with requirements that are at least as stringent as those imposed by Bioresearch, and by test data showing evidence of qualification. Qualification status is granted by the Bioresearch Integrated Test Program Board, after the applicable data is formally bought off.

The Qualification Environments for components will be contained in the Internal Environmental Specification and in the individual component specifications. The ITPP will contain definition of those components requiring qualification.

7.3.3 Acceptance Testing

Acceptance testing is performed to evaluate the workmanship and performance of each component to assure that it will function properly when it is assembled into the system and to identify defects and incipient failure conditions. This is done by subjecting the components to limited environmental stresses and analyzing data for trends and other significant indications. Test requirements and parameters will be given in the applicable component specifications.

(1) Cyclic Type Components - After fabrication, cyclic type components (such as transmitters), are given complete performance tests which simulate the end functions of the components in the operating system. Test parameters and methods are determined from an analysis of the function of each component in the system. All components are also subjected to a low-level vibration test and a high-temperature test to ascertain the effects of these environments on the performance of the component. The operability test will be defined in the Internal Environmental Specification. A final performance test is then performed. The testing approach is the same for both vendor and inhouse manufactured components. In some cases, where particular conditions deem it advisable, the vendor will perform the complete acceptance testing. In the remaining cases, GE-RESD will verify component operability and complete the tests described above, as applicable.

(2) Pyrotechnics - Since pyrotechnics (explosive one-shot devices) cannot be 100 percent tested, a destructive sampling program will be performed. A sample number of pyrotechnics from each homogeneous lot will be test fired during and after environmental conditioning lot acceptability. The sample size for each component is given in the applicable component specification. In addition, all pyrotechnics will be subjected to x-ray inspection as part of acceptance testing. The pyrotechnics will be tested as follows:

a. Prior to shipment of the pyrotechnic lot, the vendor will be required to test five samples at his facility to assure general conformance to performance requirements. Testing will be as follows:

(1) Conduct No-Fire test on all five samples prior to firing tests.

(2) Fire three at low-temperature limit.

(3) Fire two at high-temperature limit.

b. The remainder of the lot will be shipped to GE-RESD where a sample quantity will be subjected to the following program:

(1) Qualification Level Vibration

(2) Qualification Level Humidity

(3) No-Fire Test of all samples prior to firing tests.

(4) One-half of sample units fired at high temperature limit and remainder at low.

Acceptance of the remainder of the pyrotechnic lot is dependent upon successful accomplishment of the sampling tests.

The above steps are generally completed at the vendor's facility under GE-RESD surveillance.

(3) Nozzles - Nozzles are accepted at the component level on the basis of inspection only.

(4) Structures - Metal structural items are accepted on the basis of inspection. No tests generally required at the component level, except for metalographic analysis, x-ray, penetrant or other similar inspections, as required.

(5) Harness Tests - After completion of harness fabrication, harness tests will be performed in the Wire Shop prior to vehicle inspection and test. The tests included are as follows:

a. Pin-to-pin continuity

b. High potential (750 Vrms)

c. Insulation Resistance (500 VDC)

d. Shield tie resistance

(6) Pneumatic Tubing and Fitting Tests - During the fabrication cycle, in-process tubing and fittings leakage tests will be conducted.

7.4 SUBSYSTEM TESTING

7.4.1 Development Testing

Development tests will be conducted on each of the Bioresearch Module Subsystems. The ITPP will contain a definition of the test objectives, description, data to be acquired, and facility for each of these tests. A general outline of these is shown in Figure II.7-1.

Structural Development
- Vibration
- Shock
- Deployment

Thermal Control S/S Development

Electrical Power and Distribution S/S Development

Telemetry, Tracking and Command S/S Development

Attitude Control S/S Development

7.4.2 Pre-Systems Testing

During assembly of the subsystem modules, in-process harness, alignment, leakage and performance tests will be conducted. The ITPP will contain a detailed outline of these tests.

7.4.3 Attitude Control S/S Mission Type II Qualification

The test program necessary to qualify the Attitude control Subsystem for the Type II Mission will be contained in the ITPP.

7.5 SYSTEM TESTING

7.5.1 Development Tests

Development tests will be conducted on the System Development Spacecraft at the system level. Figure II.7-1 shows a brief description of these tests. The ITPP will contain a definition of the test objectives, description and data to be acquired.

7.5.2 Prototype Qualification - Mission Type I

The qualification program for the Type I Mission will be defined in detail in the ITPP. A general outline of the tests is shown in Figure II.7-1.

Electrical Performance
Electromagnetic Compatibility
Mass Properties
Spin
Vibration
Shock
Thermal Vacuum
Panel Check Out
Acceleration

7.5.3 Prototype Qualification - Mission Type II

The systems level testing required to qualify the Bioresearch Module for Mission Type II will be contained in the ITPP.

7.5.4 System Acceptance Testing

The system acceptance testing will be defined in detail in the ITPP. A general outline of the tests is shown in Figure II.7-2 and Figure II.7-3 (option to fly prototype).

Electrical Performance
Mass Properties
Spin
Vibration
Thermal Vacuum
Panel Check Out
Final Confidence

C.2

7.5.5 Pre-Launch Testing

The field testing thru launch will be defined in detail in the ITPP. An outline of these tests is shown in Figure II.7-4.

8.0 BIORESEARCH MODULE QUALITY ASSURANCE PLAN (PRELIMINARY)

8.1 INTRODUCTION

GE-RESD will provide a Quality Assurance program in accordance with NHB 5300.4 (1B) (Quality Program Provisions for Aeronautical and Space System Contractors) for the Bioresearch Program. Application of this Quality Assurance Program will vary in depth depending on the intended usage of the hardware in each phase of the program.

In general, the mockup phase will be conducted with controls applied only on specific critical points requested by Engineering. The development phase will be put under Early Release (ER) drawing controls and in-house nonconforming material controls in order to assure feedback of problem data into the qualification phase of the program. The qualification phase of the program will be conducted using issued drawings, and full nonconforming material control, and a quality assurance program which meets the requirements of NHB 5300.4 (1B).

During all phases of the program, information and documentation will be provided to NASA/ARC or ther designated Government Quality Representatives as required by the contract. GE-RESD will support the designated representatives in performance of their duties as required.

8.2 QUALITY PROGRAM MANAGEMENT AND PLANNING

GE-RESD will provide one person with the responsibility and authority to define, implement and assure that the quality requirements of the Bioresearch program are met. This person will report technically to the Program Manager and administratively to the GE-RESD Quality Assurance Manager, thus allowing direct, unimpeded access

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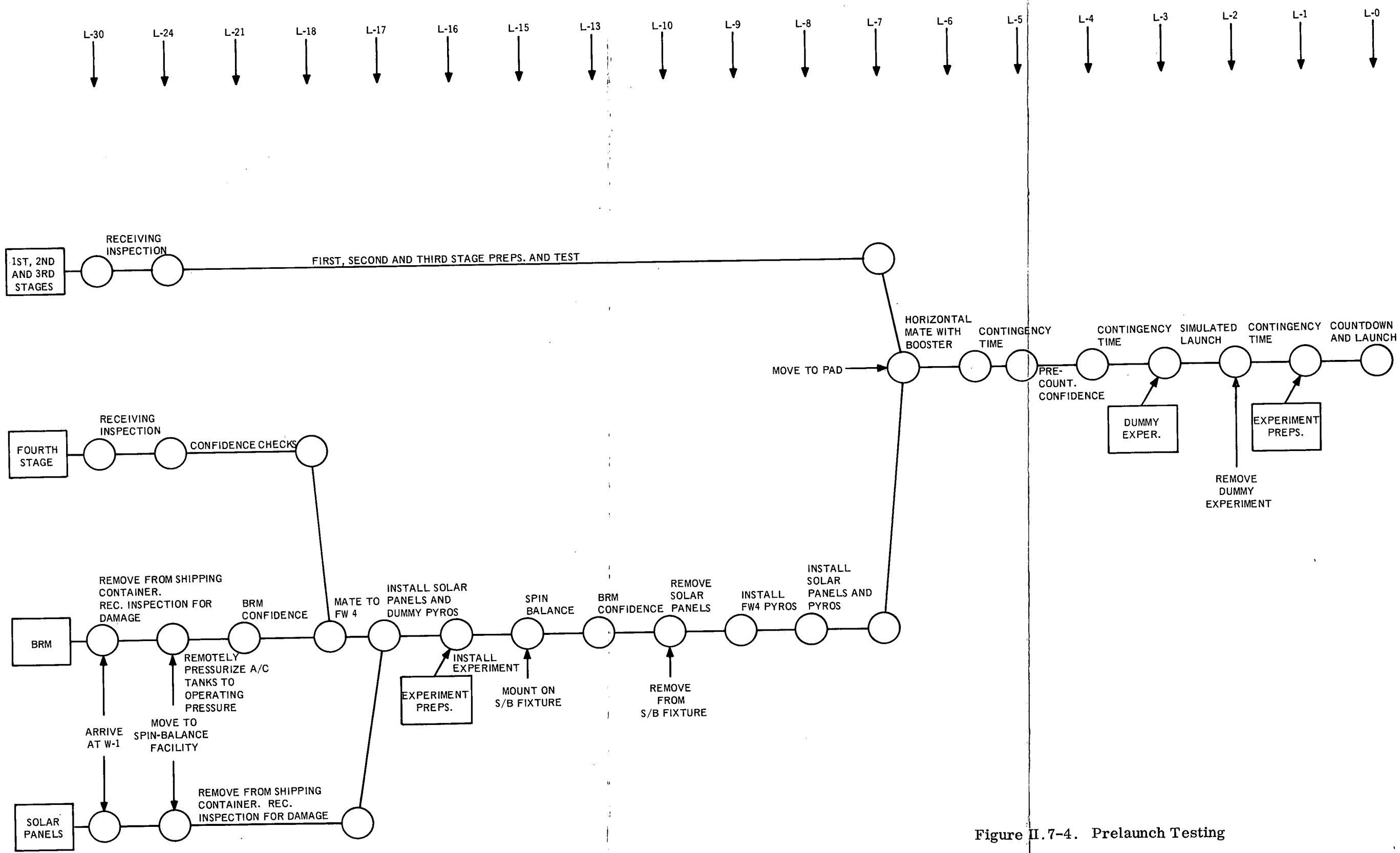

Figure II.7-4. Prelaunch Testing

to higher management in order to assure resolution of quality problems in a timely manner.

GE-RESD has in place and will implement for the Bioresearch program a training and certification program for all personnel whose skills have an effect on product quality or the determination of product quality. This program and all records pertaining to it will be available to the Government.

The GE-RESD Quality Data System will be implemented for this program. This system provides for the collection, analysis and reporting of quality data from all activities pertaining to the contract.

Quality Status Reports will be generated periodically and will include information such as significant problems, supplier performance and contractor performance.

An audit program will be implemented for the Bioresearch Program to assure that the written procedures and standards established for the program are being followed and that they are effective. This will include both procedural and hardware audits. All audits will be documented including the findings and recommendations for improvement.

A detailed Quality Assurance Program Plan will be prepared for the Bioresearch Program and will be submitted to NASA/ARC for review three months after contract go-ahead. This prelimanary plan will be used as a guide in the preparation of the detailed plan.

8.3 DESIGN AND DEVELOPMENT CONTROLS

The documentation required for hardware procurements fabrication, assembly, inspection and test will be reviewed by quality assurance personnel to assure that the information necessary to build and evaluate the hardware is included. This review is also used

to determine the inspection and test procedures and to define any tooling or test equipment required. Quality Assurance personnel will also participate in design reviews, both in-house and customer.

Drawings and specifications will be under change controls from the time they are first released under the GE-RESD Early Release (ER) system for the development phase of the contract by ER Change Notices (ERCN's) which require integration with Quality Assurance. Once the drawings and specifications are issued they are brought under the formal control of the GE-RESD Design Change Board (DCB) which evaluates and approves every change made.

8.4 IDENTIFICATION AND DATA RETRIEVAL

GE-RESD will provide for the identification and traceability of all hardware to the planning and records pertaining to its processing and quality status. Unique serial numbers will be used to provide individual control for significant hardware articles.

8.5 PROCUREMENT CONTROLS

GE-RESD has in place, and will utilize for the Bioresearch program, a vendor rating system. This system collects all information pertaining to a vendor's quality performance and rates the vendor against predetermined standards.

Vendors falling below standard or for whom GE-RESD has no previous history are audited or surveyed to determine if the vendor has a quality system which meets GE-RESD's and the contract requirements.

All procurement requests and any referenced documentation are reviewed by quality assurance personnel to assure that sufficient definition is included and to determine and incorporate quality assurance requirements into the procurement documentation.

When warranted by the complexity of the hardware, the economics of duplicating the required inspection or test equipment or other factors GE-RESD will provide source inspection at the vendor's plant. For the Qualification Phase of the program, GE-RESD will also provide completed procurement data packages to the Government quality representative for review and for his determination of the applicability of Government Source Inspection.

All hardware for the development vehicle and qualification phase of the program will be subjected to a receiving inspection at GE-RESD. This inspection will determine that the hardware meets the technical requirements and also check for damage, identification, data records and traceability. The results of receiving inspection will be fed back into the vendor rating system to maintain a measure of each vendor's performance and to determine when a vendor should be subjected to a reaudit or participate in a problem-solving clinic.

Vendors will be notified of all discrepancies found during in-house processing and will be required to provide corrective action to prevent reoccurrence.

8.6 FABRICATION CONTROLS

Planning will be prepared for use in the fabrication and assembly of hardware for use in the development and qualification phases. This planning will document the technical requirements, tooling, tolerances and processes to be used to fabricate the hardware.

Materials which are life limited in any manner will require specific controls and identification to preclude inadvertent degradation or use beyond the useful life. Cleanliness requirements will be reviewed and integrated into the planning for hardware as applicable.

Special processes are controlled through continuous auditing of the process and also inspection and testing of samples processed under the same conditions as the BRM hardware. These processes are documented and records are maintained to provide evidence of continuous quality performance.

8.7 INSPECTIONS AND TESTS

Inspection and test plans and procedures will be established for each piece of hardware to be fabricated, inspected and tested. These plans will call out the methods, tooling and acceptance criteria for each step in the processing of the hardware. These plans and procedures will be based on the engineering requirements of the drawings and specifications and will define the detail means by which product quality will be ascertained and what data is to be recorded. These plans and procedures will cover all fabrication, assembly, component subsystem and system tests performed.

Each piece of hardware to be used for the development spacecraft phase or qualification phase of the program will be subjected to the inspections and tests defined by the procedures for that part. This will include environmental testing as part of the acceptance test during the qualification phase.

A qualification test program will be established for the components during the latter part of the development phase. This plan will take into account the previous test history of each component and review it against the environmental requirements of the Bioresearch Program. Documentation will be provided to NASA/ARC for any component which GE-RESD determines to have been qualified on a prior program or to be qualified by similarity of design to a previously qualified component.

Prior to the start of systems qualification a Bioresearch Module acceptance report will be prepared and reviewed with NASA/ARC to assure agreement on the readiness of the BRM for qualification testing.

Records and data will be prepared and maintained for all inspections and tests performed. This data will be verified to assure compliance with all requirements and shall be signed or stamped by the person recording the data.

A system of pretest readiness reviews will be implemented for the subsystem, system and qualification testing of the qualification spacecraft. This will assure that the documentation, test equipment and spacecraft are ready for the testing prior to the start of testing and that any existing shortages or discrepancies will not nullify the objectives of the test.

8.8 NONCONFORMING ARTICLE AND MATERIAL CONTROL

All material or articles found to be nonconforming during an inspection or test will be documented on an appropriate form which provides for the identification, disposition and corrective action for the discrepancy. Items which can be reworked or completed to drawing, returned to the vendor or are obvious scrap will be dispositioned by GE-RESD personnel.

When an item can be used as is or repaired without affecting safety, reliability, durability, performance, interchangeability, weight or the contract objectives, it will be referred to a Material Review Board (MRB) for disposition. For the development phase of the contract the MRB will consist of a GE-RESD engineering and quality assurance representative. Copies of all development MRB case records will be provided to NASA/ARC for information. For the qualification phase a Government representative will also be an MRB member.

Nonconformances which fall outside of the scope of MRB authority but for which GE-RESD recommends usage of the hardware will be submitted in writing to NASA/ARC for final disposition.

8.9 METROLOGY CONTROLS

GE-RESD uses a system of equipment calibration which provides traceability of all measuring and test equipment to the National Bureau of Standards.

All equipment used for acceptance of contract material/articles is inspected or calibrated before use to assure that it meets its requirements. In all cases it is the goal to use equipment which is accurate to one tenth of the tolerance being measured. In cases where this is not possible or feasible, GE-RESD will notify NASA/ARC and obtain permission to use a less accurate measuring device.

8.10 STAMP CONTROLS

The stamp control system in effect at GE-RESD will be used for the Bioresearch Program. This system provides for the identification of the quality status of the hardware, associated documentation and the identification of the individual applying the stamp.

8.11 HANDLING, STORAGE, PRESERVATION, MARKING, LABELING, PACKAGING, PACKING AND SHIPPING

Articles and materials will be protected to prevent handling damage or deterioration during all phases of fabrication, inspection and test. Items being shipped will be appropriately packaged and labeled to prevent damage and to assure proper identification at the receiving site.

All shipments to a Government installation will be inspected immediately prior to shipment to assure compliance with contract requirements and all GE-RESD quality controls prior to release for actual shipment. The actual packaging and marking will be checked to verify compliance with requirements.

8.12 SAMPLING PLANS, STATISTICAL PLANNING AND ANALYSIS

Any sampling plans planned for use will be submitted for approval prior to use. These plans will be as described in existing military sampling plans in most cases.

8.13 GOVERNMENT PROPERTY CONTROL

Government property provided to GE-RESD will be controlled and its experience while under GE-RESD control will be documented. Experiment payload hardware will remain under Government control except for the time that it is installed into the Bioresearch Module for test purposes.

III. PRELIMINARY BIORESEARCH MODULE

RELIABILITY PROGRAM PLAN

1.0 INTRODUCTION

1.1 SCOPE

This preliminary Bioresearch Module Reliability Program Plan describes the reliability program GE-RESD will apply to the Bioresearch Module program implementing the requirements of NASA NHB 5300.4 (1A) "Reliability Program Provisions for Aeronautical and Space Systems Contractors", dated April 1970.

1.2 APPROACH

GE-RESD recognizes the following items as essential in the conduct of a successful Bioresearch Module reliability program:

(1) Thorough planning and effective management of the reliability effort.

(2) Definition of the major reliability tasks and their place as an integral part of the design and development process.

(3) Planning and evaluation of hardware reliability (including effects of software interfaces) through a program of analysis, test, review and assessment.

(4) Timely status indication by formal documentation and other reporting, including minutes of meetings, to facilitate control of the reliability program.

1.3 RELATION TO OTHER CONTRACT REQUIREMENTS

This preliminary reliability program plan delineates the organizations responsible for overlapping and interfacing functions such as Quality Assurance, Safety and Test in the applicable sections in which they appear. This preliminary reliability program plan is also consistent with the requirements of NASA NHB 5300.4 (1B) "Quality Program Provisions for Aeronautical and Space Systems Contractors", dated April 1970.

The following documents referenced in the NASA/ARC Work Statement and Specification A-17193 shall also apply:

NASA Publication SP-6502	Design Review for Space Systems
AIIB 5328-1	Preferred Parts and Materials List
AHB 5328-3	Screening Inspection for Electronic Parts
ARC 9	Part/Device/Material Request
ARC 23	Project Parts, Devices and Materials List
MIL-STD-461A	Electromagnetic Interference Requirements
AFETRM-127-1	USAF Range Safety Requirements

1.4 ACTIONS AND PREROGATIVES OF THE GOVERNMENT

1.4.1 General

GE-RESD and its suppliers will cooperate fully with NASA/ARC in their examination, evaluation and inspection of any reliability-related work, data and documentation generated during the contract.

1.4.2 Separate Reliability Evaluation for NASA

GE-RESD and its suppliers will cooperate fully with any reliability evaluation contractor which NASA/ARC may employ.

1.4.3 Inputs to Data Exchange Programs

NASA/ARC may utilize any portions of the reliability program data generated under the contract as input to Government data exchange programs.

1.5 RELIABILITY PROGRAM DOCUMENTS

GE-RESD will submit reliability program documents to NASA/ARC for information, review or approval in accordance with the Contract Data Requirements List (CDRL).

All reliability documents generated on the contract, not required for submittal, will be filed and made available to NASA/ARC upon request.

1.6 GLOSSARY OF TERMS

GE-RESD will utilize the glossary of terms contained within NHB 5300.4 (1A)-Appendix C.

1.7 RELATED DOCUMENTS

GE-RESD will consider the NASA reliability related documents contained within NHB 5300.4 (1A)-Appendix E as contractual guides. Those indicated by the work statement and specification as compliance documents will be utilized as contractual requirements.

1.8 REQUIREMENT DETAILS TO BE SPECIFIED SEPARATELY

GE-RESD will utilize, as baseline requirements, those which are delineated in this preliminary reliability program plan. GE-RESD will also place these requirements similarly on suppliers.

2.0 RELIABILITY PROGRAM MANAGEMENT

2.1 ORGANIZATION

The Manager, System Analysis and Requirements Laboratory, who reports to the Manager, Systems Engineering Management Laboratory, within the Research and Engineering Department, is responsible for the conduct of all reliability programs at GE-RESD. (Figure III.2-1) A senior SA&R engineer representing the Manager of SA&R will serve as the Bioresearch Program Reliability Team Leader. He is a responsible member of the Chief Engineer's Research and Engineering staff on the Bioresearch program management team responsible for the planning, monitoring, controlling and reporting of the reliability efforts on the program. He interprets the customer's reliability requirements and tailors the existing GE-RESD Policies and Instructions and Reliability Operating Procedures (ROP's) to meet the specific needs of the program. The Manager, SA&R is responsive to the Reliability Team Leader's requirements and is responsible for the technical excellence of the work performed. This matrix type organization, as practiced at GE-RESD, combines the best merits of both a strong program management-type organization and an in-depth functional

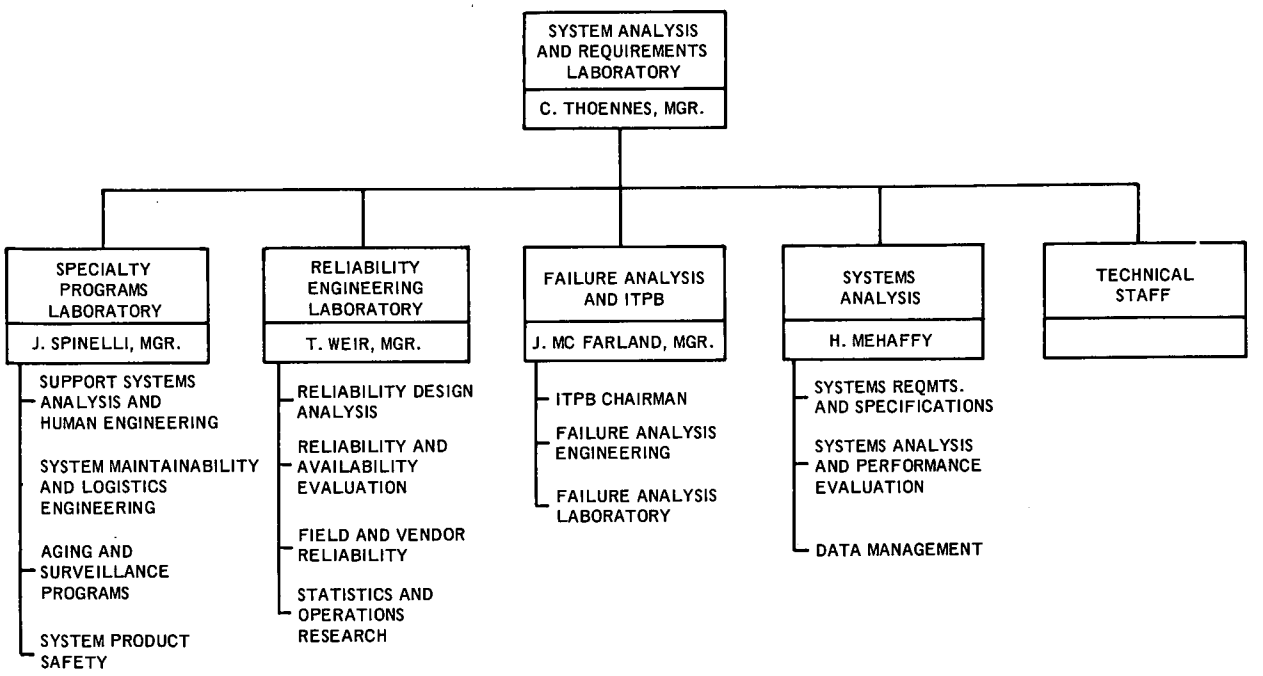

Figure III.2-1. System Analysis and Requirements Laboratory Organization

line-type organization. Overall GE-RESD reliability policy is determined by the Manager, Systems Engineering Mangement Laboratory, who reports at the R&E Department staff level.

2.2 RELIABILITY PROGRAM PLAN

2.2.1 General

An update of this preliminary Bioresearch Module reliability program plan will be submitted in accordance with the requirements of the CDRL. Upon approval by NASA/ARC, the plan together with the reliability program control reporting system will serve as the master planning and control document for the reliability program. This plan will be updated periodically and revisions submitted to NASA/ARC for approval in accordance with the CDRL prior to implementation.

2.2.2 Contents

The contents of the updated Bioresearch Module reliability program will be in accordance with NHB 5300.4 (1A).

2.2.3 Separate Site Plans

Separate site plans defininig the reliability efforts to be conducted at the separate sites will be generated as a part of the updated reliability program plan in accordance with the CDRL.

2.3 RELIABILITY PROGRAM CONTROL

2.3.1 General

GE-RESD will utilize its existing effective system for management, control and audit of the Bioresearch Module reliability program. A preliminary listing of each reliability task, the applicable Reliability Operating Procedure (ROP), and the preliminary reliability program plan reference paragraph is included in Table III.2-1.

The Reliability Management Matrix is a graphic display which permits program and functional reliability management to continuously monitor the technical progress and the schedule status of major elements of the reliability programs as they apply to system, subsystem and component. These include the accomplishment of the following program elements: reliability apportionment, design analysis, parts application review, design review, supplier reliability program, qualification buyoff, failures, RFMA's, FMEA's and specifications.

2.3.2 Reliability Program Reviews

Formal reviews of the Bioresearch Module reliability program will be scheduled and conducted, in accordance with contract requirements. Participating in these reviews will be GE-RESD and NASA/ARC project offices and reliability representatives. Additional attendees for presentations, discussions, etc. may be invited by either NASA/ARC or GE-RESD.

TABLE III.2-1. RELIABILITY TASK MATRIX

Reliability Program Plan And Ref. Para.	Reliability Operating Procedure
1.0 Introduction	
2.0 Reliability Program Management	
2.1 Organization	--
2.2 Reliability Program Plan	A-1.0 Preparation of Reliability Program Plan
2.3 Reliability Program Control	A-2.0 Reliability Program Review
2.4 Reliability Progress Reporting	A-3.0 Reliability Reporting
2.5 Reliability Training	F-1.0 Reliability Training
2.6 Supplier Control	E-1.0 Supplier and Subcontractor Reliability Program E-2.0 Subcontractor Work Statements
2.7 Reliability of Gov. Furn. Prop. (GFP)	B-7.0 Equipment Integration (GFE & Assoc.)
3.0 Reliability Engineering	
3.1 General	--
3.2 Design Specifications	D-2.0 Critical Item Control E-3.0 Preparation & Use of Specifications
3.3 Reliability Prediction	B-1.0 Reliability Requirement Studies B-2.0 Reliability Apportionment & Math Models B-3.0 Reliability Prediction
3.4 Fail. Mode, Effects & Crit. Anal.	B-6.0 Failure Mode & Effects Analysis

TABLE III.2-1. RELIABILITY TASK MATRIX (Continued)

Reliability Program Plan And Ref. Para.	Reliability Operating Procedure
3.5 Maintainability & Human Factors	F-2.0 Human Engineering G-3.0 Maintainability
3.6 Design Review Program	B-4.0 Reliability Design Review
3.7 Problem/Failure Reporting & Corr.	C-1.0 Failure Analysis and Reporting
3.8 Standardization of Design Practices	--
3.9 Parts and Materials Program	D-4.0 Parts Control
4.0 Testing & Reliability Evaluation	
4.1 General	--
4.2 Reliability Evaluation Plan	G-2.0 Reliability Data Requirements
4.3 Testing	B-5.0 Statistical Reliability D-1.0 Storage and Aging D-3.0 Pre-Acceptance Operational Limits G-4.0 Environmental Qualification
4.4 Reliability Assessment	G-1.0 Reliability Measurement and Demonstration
4.5 Reliability Inputs to Readiness Reviews	A-2.0 Reliability Program Review
4.6 Reliability Evaluation Program Reviews	A-2.0 Reliability Program Review

Ten working days prior to each reliability program review meeting, GE-RESD will supply NASA/ARC with a proposed agenda. Comments will be solicitated and a firm agenda will be furnished to NASA/ARC five working days prior to the scheduled meeting.

GE-RESD will prepare minutes of each reliability program review meeting and submit them to NASA/ARC within ten working days. Reliability program plan revisions resulting from the review meeting will be submitted to NASA/ARC for approval within 30 working days following the meeting. All approved revisions are expected to be included in the reliability plan. However, the required change will be implemented within the time period agreed to during the review meeting.

2.4 RELIABILITY PROGRESS REPORTING

2.4.1 General

A Bioresearch Module Reliability Documentation Center will be established and maintained for the Bioresearch program to retain all the reliability documentation generated throughout the program.

2.4.2 Reliability Progress Reports

Two basic types of reliability progress reports will be prepared to inform the Chief Engineer, Program Management, GE-RESD reliability functional management and NASA/ARC of the status of the reliability program.

Periodic progress reports will be submitted as a part of the Bioresearch Program Monthly Technical Progress Reports. These reports will include the Reliability Management Matrix and text describing the technical progress of the reliability program, reliability problem areas, significant events, and pertinent technical reports and data.

Reliability program control reports on cost and expenditure data will be submitted as a separate section of the periodic financial and management reports.

2.4.3 Summary of Technical Documentation

Technical documentation will be submitted in accordance with the CDRL.

2.5 RELIABILITY TRAINING

A Bioresearch Module oriented reliability indoctrination pamphlet will be generated and distributed to the Bioresearch team. In addition, reliability items of special interest to Bioresearch personnel will be disseminated via bulletins and newsletters.

2.6 SUPPLIER CONTROL

2.6.1 General

The Bioresearch Subcontractor and Supplier Reliability Program is designed to assure that subcontractors and suppliers meet the reliability standards required for this program. This program is established on division procedures developed at GE-RESD for the selection and control of suppliers.

2.6.2 Reliability Program Requirements for Suppliers Required to Utilize Reliability Programs

For major subcontracts the work statements and specifications will impose appropriate provisions of NASA Reliability Publication NHB 5300.4 (1A) which will include a reliability program plan subject to the approval of Bioresearch Reliability. A Supplier and Subcontractor Reliability Program Requirements document will be generated for the Bioresearch Program. All of the requirements of this document, excepting those paragraphs dealing with components, will be applicable on major subcontractors. Competent reliability personnel will be assigned to monitor reliability performance of the subcontract directly through plant visits and indirectly through technical representatives acting under instructions of Bioresearch Reliability.

For components considered critical to mission success, reliability requirements will be imposed in the specification and/or work statement for the suppliers. The extent

to which these requirements apply shall be determined on the basis of an evaluation of that which is necessary to assure attainment of specified reliability goals and/or requirements and to assure fulfillment of the applicable specification and drawing requirements.

Bioresearch Reliability will assure the adequacy of supplier reliability capabilities as follows:

(1) Negotiate implementation of reliability requirements by vendor.
(2) Monitor vendor compliance with reliability requirements.
(3) Follow up on any reliability oriented action item imposed on vendor through Design Review, Failure Analysis or investigations.
(4) Visit vendors of critical items to keep abreast of vendors' reliability status.
(5) Define special reliability oriented action required by program from vendors. Negotiate and schedule these actions with vendors to satisfy program requirements.
(6) Bioresearch Reliability personnel will visit suppliers of critical items to participate in the supplier's design review.

Subcontractors and suppliers of major components will also be required to submit periodic progress reports listing problem areas, the supplier's plan for solving the problems described, and any recommendations for design simplification or reliability improvement of the equipment. Visits will be made to suppliers to monitor reliability performance or when problems arise which are best handled by personal contact and surveillance.

2.6.3 Minimum Reliability Controls for Items Not Requiring Reliability Programs

The reliability of all components obtained from suppliers who are not required to maintain a formal reliability program will be controlled by specifications responsive to the applicable reliability and other mission criteria and expressed in terms of conformance to readily measurable criteria. Minimum requirements will include:

(1) Failure reporting and correction.
(2) Use of selected parts.
(3) Equipment logs.
(4) Control of design changes.
(5) Control of special processes as required.
(6) Use of clean rooms as required.
(7) Adherence to specified workmanship standards.

2.7 RELIABILITY OF GOVERNMENT FURNISHED PROPERTY (GFP)

This paragraph is not applicable. As presently defined by the customer, NASA/ARC will be responsible for the integration/reliability of experiments.

3.0 RELIABILITY ENGINEERING

3.1 GENERAL

An essential requirement of the reliability engineering tasks is the systematic removal of design defects and other deterrents to high reliability before they are incorporated into the hardware.

Each of the basic elements of the reliability engineering program described in the following paragraphs contributes in some manner to the detection and removal of design and manufacturing defects. Many of the elements, due to their proven contribution to defect identification and removal, are actually a part of the in-line engineering design effort, contributing in real-time rather than being used as an after-the-fact audit.

3.2 DESIGN SPECIFICATIONS

The implementation of an orderly flow and buildup of specifications and program oriented documentation will be accomplished by a Bioresearch Module specification engineer. The systems engineer will prepare and release the system specification.

Subsidiary specifications as indicated in the specification tree will be prepared and released in similar manner by the Bioresearch Module subsystem and component engineers. That is, subsystem specifications will be derived from the system specification. Similarly, component specifications will be evolved from the subsystem requirements and internal environmental requirements.

The environmental criteria, internal and external, will be prepared by the Bioresearch Module systems engineer and will be the requirements section for the component and system test specifications, respectively.

A Bioresearch Module reliability engineer will review all design specifications on the system, subsystem and component levels. Concurrence by the reliability engineer will validate that the specifications reviewed reflect performance requirements, environmental requirements, test criteria, reliability apportionment and all pertinent design parameters. These specifications will be prepared and issued and will be submitted to NASA/ARC for information, review or approval in accordance with the CDRL. Subsequent changes thereto will be subject to the procedures for changes as described in the Configuration Management Plan.

3.3 RELIABILITY PREDICTION

3.3.1 Development of Reliability Predictions

The Bioresearch Module system reliability design objectives including success/failure criteria for the six-month mission requirement and two year design goal BRM (less experiments) will be developed and apportioned to the subsystem and component levels early in the program. State-of-the-art, criticality, complexity, duty cycle and environmental factors will be employed in apportioning the Bioresearch Module reliability design objectives.

A preliminary reliability prediction will be performed on components, subsystems and the system early in the design phase prior to the preliminary design review (PDR). The generic procedure to be followed is:

(1) Establish a reliability block diagram and model in terms of functions.

(2) Establish the block diagram and model of each of the functions in terms of the components or functional elements of components.

(3) Insert into each model the most realistic generic failure rates available and perform the necessary computation to arrive at the estimated reliability.

A final reliability prediction will be performed prior to the final design release on components, subsystems and the system and will serve as an important input to the critical design review (CDR). This final prediction will be based on specific performance requirements and environmental conditions of the mission using techniques

described in MIL-HDBK-217. Parts usage and application data, including failure modes and effects, is supplied by the responsible design engineers. This information is then used by the Bioresearch Module design reliability engineers to perform the analyses. Results of the analyses are identification of high probability of failure areas and the recommendations of methods for their elimination. Recommendations for design improvement will be submitted to the responsible design engineers. Action taken by the designer will be reported by the Bioresearch Module reliability design analysis engineer and included in the Monthly Technical Progress Report.

3.3.2 Functional and Equipment Block Diagrams

Reliability mathematical models and functional and equipment block diagrams will include the apportioned and predicted reliability and will be kept current to reflect changes in system configuration. These models will reflect the functional relationship of the primary equipment as well as built-in redundancy, back-up operational equipment and alternate operational modes.

3.4 FAILURE MODE, EFFECT AND CRITICALITY ANALYSES (FMECA)

The failure mode, effect and criticality analysis is essentially derived from a detailed and systematic review of a component design down to the circuit/subassembly level looking for ways in which the component can fail to meet its functional performance requirements, and the causes or hazards that would precipitate these failures. The objective of this search is to discover critical failure areas and take corrective action to minimize the probability of such failures occurring. These FMECA's are inherently engineering analyses associated with effective design practices and are accomplished in real time as the design evolves. Primary responsibility for the analyses is assigned to the reliability design analysis engineers with inputs provided by the design engineers. Preliminary and final FMECA's will be issued as part of the preliminary and final reliability design analyses. Action items will be assigned and followed up to a conclusion.

3.5 MAINTAINABILITY OF THE SYSTEM AND ELIMINATION OF HUMAN-INDUCED FAILURES

Maintainability consideration will be a design factor primarily directed at the failure/repair cycle at and above the component level. The objective is to minimize handling and disassembly associated with identifying, gaining access to, and replacing failed equipment.

Maintainability design guidelines will be utilized during internal design reviews to identify maintainability problems and opportunities for human-induced failures.

3.6 DESIGN REVIEW PROGRAM

3.6.1 Design Reviews by the Contractor

Design reviews will be held on the system, subsystems and selected significant components in accord with GE-RESD Instruction 3.9. A design review engineer will act as chairman at all internal reviews. His principal objective is to help the design engineer check the adequacy of his design. A prepared checklist is used as a guide. Design reviews, customer and internal, including those at subcontractors' plants, will be conducted as called for in the contractual requirements. Additional design review meetings will be scheduled as deemed necessary to adequately cover the design review requirements of an item. Participation in the customer design reviews will include appropriate representatives of Design Engineering, Manufacturing, Reliability, Quality Assurance, Parts Engineering and the Program Office, according to the problems anticipated. The dates and location of each customer review will be confirmed and descriptive material selected from the list in Table III.3-1 will be circulated to the consultants and NASA/ARC representatives ten working days before the design review.

Action items and recommendations will be issued by the Design Review Chairman to all participants within five working days of the review meeting and formal minutes

TABLE III.3-1. FORMAL DESIGN REVIEW PACKAGE - TYPICAL CONTENTS AS AVAILABLE AND APPLICABLE

SYSTEM AND SUBSYSTEM DESIGN REVIEWS

1. Bioresearch Module System Specification
2. Subsystem Specification.
3. Block diagram(s) of all significant functions and/or components (with transfer functions if desirable).
4. List of all significant components.
5. Mission profile of most significant parameter(s).
6. Interface Specification.
7. Electromagnetic Compatibility Management Plan.
8. Electromagnetic Compatibility Design Specification.
9. Electromagnetic Compatibility Test Specification.
10. Subsystem Test Program/or Specification.
11. Significant layouts or drawing showing location of components, etc.
12. Applicable Quality Assurance Documents
13. Any pertinent analysis or analyses (including Reliability data).

COMPONENT DESIGN REVIEWS

1. Component Specification with drawings, parts list(s).
2. Layouts
3. Electrical schematic and/or mechanical schematic drawings.
4. Test Specifications, test data.
5. Applicable Quality Assurance documents.
6. Any pertinent analyses

of the meeting will be issued by the Bioresearch Module Design Review Chairman within 15 working days after the design review meeting. Recipients of the action items and minutes will be invited to send written technical comments promptly to the responsible Design Review Chairman for inclusion as addenda to the minutes of the meeting. Followup of the action items will be pursued to assure that corrective action has been taken.

3.6.2 Design Reviews by Suppliers

Design reviews for suppliers will be conducted. The supplier will be required to perform two design reviews. The reviews are considered an extension of GE-RESD in-house design reviews and will be conducted in a similar way. The supplier will be required to notify GE-RESD 21 days in advance of the review. Documentation and notification requirements of 3.6.1 are applicable.

3.6.3 Design Changes

All design changes will be processed by the Bioresearch Module Design Change Board described in the Configuration Management Plan. Every design change is reviewed for possible effect on design status. When any design change(s) is judged by any member to warrant a design review, a design review will be scheduled to evaluate the overall effect of the change(s).

3.7 PROBLEM/FAILURE REPORTING AND CORRECTION

3.7.1 Failure Reporting

Failure reports will be required from all test areas, including GE-RESD, subcontractors and suppliers according to GE-RESD Instruction 3.14 and Division Standard 118A1679. The methods and procedures for the initiation and collection of failure reports are defined in the Quality Assurance Program Plan. Reporting will be accomplished at the component, subsystem and system levels during acceptance, qualification and flight test program. AGE failures and software problems will be included. The Failure Analysis Engineer will review and classify for significance (see Table III.3-2) each failure. All failures will be reported to NASA/ARC within 24 and 48 hours after occurrence at GE-RESD and supplier respectively.

3.7.2 Failure Analysis Correction

The failure analysis engineer will analyze all failures. The decision to hold or not to hold a formal Failure Analysis Board (FAB) meeting will be made by the failure analysis

TABLE III.3-2. FAILURE CLASSIFICATIONS

Critical Failure - A failure, or performance degradation which would cause a safety hazard, unacceptable degradation of performance or loss of mission of space system.

Major Failure - A performance degradation in excess of tolerance limits, which in use, would not cause any of the effects of a critical failure, but which might affect the reliability of the system due to cumulative tolerance build-up allowances.

Minor Failure - All failures other than critical or major which are determined to have had no significant effect on the ability of the item to perform in the manner intended.

Secondary Failures - Failures resulting from other failures. A secondary failure shall be separately identified. The failure directly causing the secondary failure shall be identified by reference to its serialized failure report number and classified Critical, Major or Minor.

Analysis and recording of failures shall also differentiate between those due to equipment failure and those due to human error in designing, processing, handling, transporting, storing, maintaining, and operating the equipment.

Digital codes for Failure Summary Report:

Failure	Code
Critical	3
Major	2
Minor	1

Only Critical and Major Failures will enter the Reliability Analysis computations.

engineer. For those failures not requiring a formal analysis, the failure analysis engineer in performing his informal analysis will be responsible for the activities necessary to determine the failure mode, cause of failure, corrective action required and follow-up necessary to insure the corrective action has been taken.

Formal failure analysis is the mechanism by which GE-RESD will identify major problem areas, recommend corrective actions to improve the reliability, and close the loop on failures to preclude their recurrence.

Formal failure analysis will be conducted on all critical and major failures by the Bioresearch Module Failure Analysis Board, in accordance with GE-RESD Instruction 3.13 and Division Standard 118A1680. In addition, repetitive failures that suggest lowered reliability will be analyzed.

The Bioresearch Module Failure Analysis Board will be composed of the following personnel: Reliability Failure Analysis Engineer as Chairman, the Design Engineer, the Quality Assurance Engineer, Subsystem Engineer, and Specialists (such as heat transfer, structure, materials and processes, parts) as required. The NASA/ARC in-plant representative will be invited to each formal failure analysis meeting.

The Failure Analysis Board will review the history of the failure(s), pinpoint the exact mode and cause of failure, determine the necessary corrective action, specify effectivity and follow-up to assure that this corrective action is taken, and issue a Failure Analysis Report. The Failure Analysis Board is supported in establishing the physical cause of failure by the GE-RESD Failure Analysis Laboratory and the Parts Investigation Laboratory as required.

3.7.3 Periodic Reports

The Failure Summary Report will document all reported and transmitted failures which have occurred on Bioresearch Module qualification and flight equipment. The Biosearch Module Failure Summary Report (FSR) will be issued quarterly. Modification or additional change sheets will be disseminated monthly and included in the Monthly Technical Progress Report.

The Failure Analysis Follow-up Report (FAFUR) lists the corrective actions from failure analyses, the person responsible for taking action, and a date for completion of the action. This FAFUR will be issued to assure follow-up of FA action items.

3.7.4 Risk Statements

Failures which have not been closed by the completion of the qualification and acceptance test programs will have Risk Statements prepared for inclusion in the qualification and acceptance test reports.

3.7.5 Failure Close-Out with NASA/ARC

GE-RESD will maintain complete and accurate records of failure close-out status by:

1. Maintaining a current status of open failures and action items, and present this status at the daily program meetings.
2. Transmit to NASA/ARC a copy of failure report with definition of corrective action taken.
3. Schedule and coordinate meetings with NASA/ARC to obtain concurrence with the GE close-out of failures.

A flow diagram showing the routing of failure reports and associated documents as shown in Figure VII.3-1.

3.8 STANDARDIZATION OF DESIGN PRACTICES

3.8.1 GE-RESD Standards Program

The GE-RESD Standards Program is based upon four basic principles.

1. Integrated technical decisions.
2. Mutually acceptable definition and documentation.
3. Rapid retrieval of information.
4. Specifically assigned areas of responsibility.

The Standards Program maintains and issues to engineers standards on parts, materials and processes, technical procedures and drafting manuals. These standards consist of military or industry standards which have been adopted for use by GE-RESD as well as GE-RESD generated standards for specific items for which military standards do not exist or do not satisfy the needs required.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

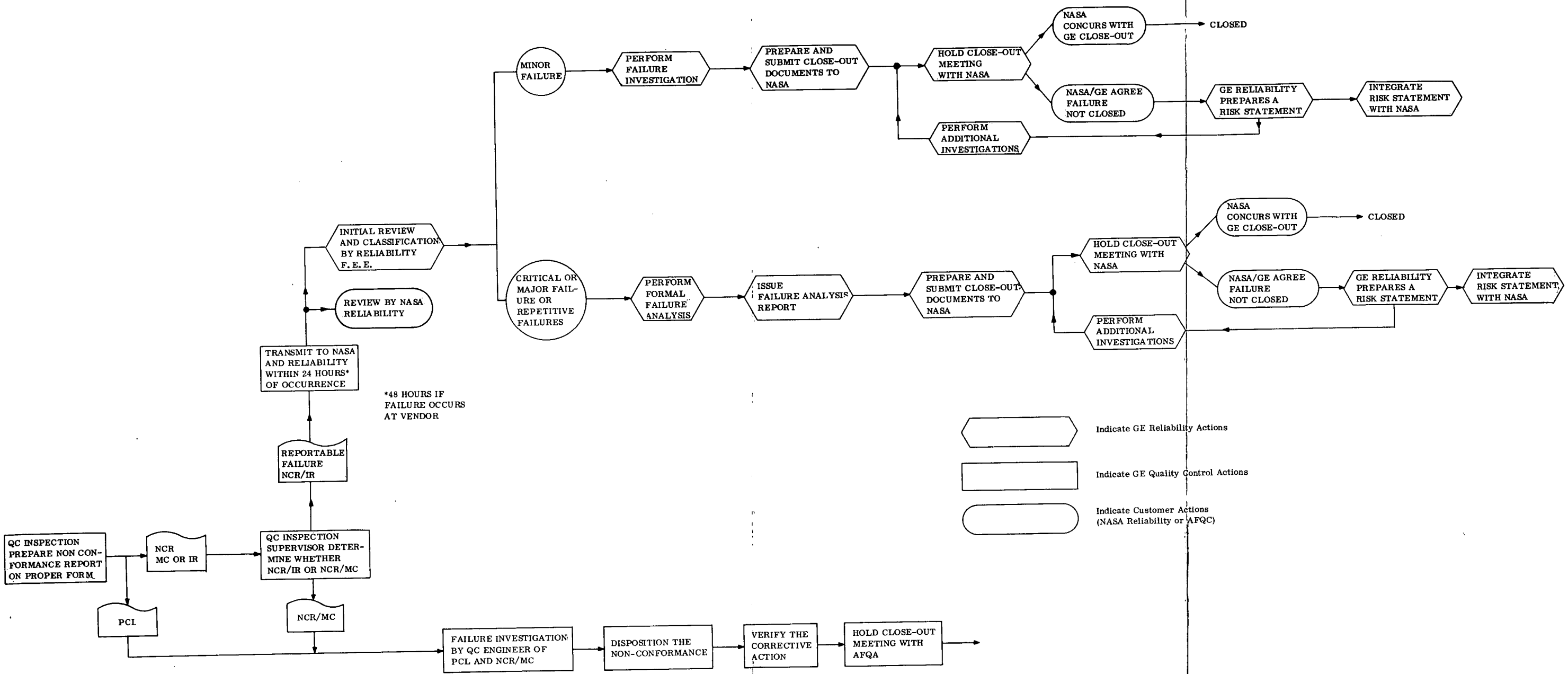

Figure III.3-1. Failure Report, Routing and Documents

As a base for the Bioresearch Module program, maximum use will be made of the standards which have already been generated by GE-RESD. When additional standards are required in any of the areas, they will be developed to meet the required need.

Standards issued have as their primary purpose the definition of discrete solutions to recurrent problems.

All standards which are issued are completely integrated throughout the functional sections of GE-RESD, in accordance with Division Instruction 3.7, and the producer of items conforming to the standards so that there is a common agreement between the originator, user and producer.

Personnel in all sections of GE-RESD are supplied with the standards manuals.

Standards manuals are divided into four categories. The first category, Application and Reliability Data, has three volumes describing the application and reliability data on electronic parts, mechanical parts, and materials and processes. Included in this first category of volumes are failure rates, derating factors, mounting and packaging considerations, the effects of environments and failure modes.

The second category is the Drafting Practice Manual. This volume contains the drafting practices and procedures established in compliance with Governmental Drafting Specifications and General Electric Standards Practices.

Volume III Standards contains the third category of standards: electronic parts, mechanical parts, and materials and processes.

The fourth category is the Volume IV Standards, which covers design standard practices.

All these standards and volumes will be utilized to the maximum extent possible in the Bioresearch Module program.

Additions and generation of new standards will be made through the Standards Manuals as they are required for the Bioresearch Module program.

These revisions or additions to the Standards Manual will be processed through the GE-RESD Standards Review Board made up of representatives of the individual sections of GE-RESD in accordance with Division Instruction 3.7.

3.8.2 Data Exchange Programs

GE-RESD is active in the Interservice Data Exchange Program (IDEP) and the Electronic Component Reliability Center, ECRC, at Battelle Memorial Institute, data exchange programs.

In these programs a wealth of data has been obtained and assimilated within the Standards Program.

With this background data available prior to the use of any new part within the Bioresearch Module program, all data available in the data exchange programs is reviewed to determine whether data available provide the required information. Primarily, the data in the exchange program serve two basic functions:

(1) They provide substantiation of the quality of the product and the vendor or vendor's manufacturer.

(2) They provide a source of supplemental data for specialized requirements.

By using the data from the data exchange programs and supplemental data from GE-RESD facilities, unnecessary testing will be eliminated.

All new reports from the data exchange programs are reviewed when received to assure maintenance of all data on parts and vendors are current.

NASA/ARC will be requested to provide GE-RESD with NASA experience data (particularly flight) on Bioresearch Module parts and components utilized on other NASA programs. GE-RESD will integrate NASA generated reliability data on parts and

components common to Bioresearch Module with other available data on similar parts and components. When such information is not available, GE-RESD will request NASA/ ARC assistance in obtaining such data.

3.9 PARTS AND MATERIALS PROGRAM

3.9.1 Parts and Materials Group

The Bioresearch Module Parts and Materials Program will be established to assure the use of selected and controlled parts and materials of the reliability and quality required by the Bioresearch Module program. This program will be carried out by specialists of the Parts Engineering group of the Design Engineering Section at GE-RESD. This group has been established to act as advisors to the design groups in the selection and application of parts and materials and to conduct the required parts program.

3.9.2 Parts Selection

The selection of parts for the Bioresearch Module program will be made in accordance with the existing GE-RESD Instruction 3.19 covering the use of standard parts. Assurance that in their application standard parts selected will meet the Bioresearch Module flight requirements will be achieved through parts application and design reviews. The approved parts list is called out in the specifications, which in turn are called out on the drawings. Quality Assurance inspects to the drawings for all prime hardware which will assure compliance with the selected parts list.

3.9.3 Parts and Materials Specification

Adequate definition of component parts and materials for use in the Bioresearch Module program will be provided by the use of existing standard drawings and specifications where such documents of suitable quality have been prepared for use on other programs. Where adequate specifications do not exist, new detailed purchase specifications will be prepared indicating the specific part, approved suppliers, pertinent

requirements, screening techniques, quality assurance provisions and protective packaging requirements.

3.9.4 Parts and Materials Qualification Tests

Every effort will be made to use parts and materials for which adequate qualification data exists. In this connection, all existing information that has been accumulated by GE-RESD, vendors, military agencies, test data interchange programs--such as IDEP and other sources--will be utilized. In addition, certain part types which have multiple usage and/or are used in critical applications will be subjected to qualification testing. Part qualification status will be maintained and will be submitted to NASA/ARC for approval. Status will be reported on the Bioresearch Module Qualification Status List.

3.9.5 Approved Parts and Materials Lists

The Selected Parts Lists will be formulated by the cognizant parts specialists of the Parts Engineering group who, in conjunction with the design engineers, will determine the types of component parts which will be utilized in the program. The basis for selection will include inputs as to the kinds of parts needed and the availability of qualification data for each part as well as the background and experience relative to prior usage. Within each generic category of parts, specific part types and suppliers will be selected with the goal of obtaining quality and reliability consonant with program needs and limiting the number of different part types. Only parts covered by GE-RESD standards will be included in the Selected Parts Lists. Where both high reliability and other standard parts are shown on the AVE selected parts lists, the high reliability part will be used. The Bioresearch Module and AGE Selected Parts Lists will be submitted to NASA/ARC.

3.9.6 Parts and Materials Review

Prior to the finalization of the design of each component, a thorough Part Application Review will be performed to verify not only the use of proper parts, but also the

proper use of parts. This review will be designed to determine the applicability of each part in the design to mission profile design requirements incorporating means such as stress analyses for electronic assemblies. The means of performing the Part Application Reviews will first be through the compilation of information on Parts Usage and Application Data forms obtained from the design engineer. The information thus compiled will be analyzed and a formal Part Application Review document will be issued.

3.9.7 Part Consultative Services

Application and reliability data for electronic parts, mechanical parts, and materials and processes have been prepared and issued as part of the Division standards program. The type of information that is contained in the issued application guides includes derating information, performance characteristics, packaging and monitoring considerations, failure rate curves, end of life limits, failure modes, and significant do's and don't's to be followed in the design. In addition to the availability of the application guides for use on the Bioresearch Module program, guidance will be provided to design engineers concerning part application, availability, selection and reliability through individual consultations as a part of design reviews, reliability design analyses and failure analyses.

3.9.8 Part Failure Investigations

As part failures occur during the course of the Bioresearch Module program, a part failure analysis will be conducted. The actual failed part will be obtained and analyzed by the GE-RESD Parts Investigation Laboratory. Characteristic checks and dissections of the part will be performed to confirm failure modes, determine causes of failure and eliminate the potential failure cause by recommended improvement in parts selection, and application of circuit design. Parts Analysis Reports will be issued.

4.0 TESTING AND RELIABILITY EVALUATION

4.1 GENERAL

The GE-RESD Bioresearch Module reliability program will include acceptance and qualification testing only and no reliability evaluation tests since only qualification and two Type I and two Type II flight models will be produced.

4.2 RELIABILITY EVALUATION PLAN

No Bioresearch Module reliability evaluation plan will be prepared for the basic reason as stated in paragraph 4.1.

4.3 TESTING

In accordance with GE-RESD Instruction 3.12, an Integrated Test Program Board (ITPB) will be organized to:

(1) Assure that the proper concepts of testing are used.

(2) Verify that test specifications define and require tests for all requirements of the program.

(3) Evaluate the results of these tests (as presented in formal test reports) to determine whether qualification should be granted to components and systems.

This ITPB will consist of representatives from each of the following functions:

(1) Reliability (Chairman).

(2) Design Engineering.

(3) Quality Assurance.

(4) Systems Test and Operations.

(5) Specialists.

(6) Program Office.

In addition to the above, NASA/ARC will be notified of each ITPB meeting and invited to attend.

This ITPB will be responsible for qualification of equipment by:

(1) Review of qualification specifications to determine agreement of testing requirements with program requirements, and to approve such documents as valid bases for qualification. The chairman shall approve these documents by signature.

(2) Review of requests for waivers of, or deviations from, specification test requirements.

(3) Review of data developed in qualification tests, confer or withhold qualification based on such reviews and issue formal qualification compliance reports. Removal of qualified status when necessary due to results of later tests of the qualified equipment.

(4) Review of failure reports, failure analyses, and design changes (AN's) for their effects on the qualification status of equipments.

(5) Issue official qualification status reports.

(6) Whenever a specification is not approved, or when qualification is withheld or rescinded, the ITPB defines the deficiencies, in writing, through the chairman and furnishes definite, precise requirements directed toward achieving qualified status.

The program for accomplishment of the above consists of four phases as follows:

(1) Phase I -- Review and approve external and internal environment specification for the BRM program. Review and approve the specification for each component, and review and approve the BRM system qualification specification.

(2) Phase II -- Review the available data on all components which have been previously qualified on other programs and determine whether equipment must be subjected to tests at certain additional environments, to obtain qualification to its specification.

(3) Phase III -- Review the tests performed on new components and grant or withhold qualification based on these results.

(4) Phase IV -- After necessary action (if any) is performed to obtain qualification of all components, qualification tests will be performed on the system and the results reviewed for qualification.

Qualification Compliance Reports will be submitted to NASA/ARC for review.

4.4 RELIABILITY ASSESSMENT

Not to be performed for reasons of paragraph 4.1.

4.5 RELIABILITY INPUTS TO READINESS REVIEWS

Reliability will provide the necessary inputs for, and support the various Bioresearch Program Readiness Reviews. These will include the in-house Pre-ship and field Flight Readiness Reviews to be conducted on each of the four flight test models. Reliability will provide a risk assessment for each open failure as a result of the qualification and acceptance test programs (reference 3.7.4). Each risk assessment will be integrated with NASA/ARC Reliability personnel prior to presentation at the Readiness Review Meeting.

4.6 RELIABILITY EVALUATION PROGRAM REVIEWS

Not to be performed for reasons of paragraph 4.1.